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# The Leeway of an Open Boat and Three Life Rafts in Heavy Weather


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RESEARCH & DEVELOPMENT CENTER
UNITED STATES COAST GUARD

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16. Abstract


A field test of the leeway of three search and rescue (SAR) craft was conducted during November-December 1995 by the U.S. Coast Guard Research and Development Center and the Canadian Coast Guard. The experiment was conducted on the Grand Banks of Newfoundland. The SAR craft included a 5.5 meter wooden-planked open boat common to the Newfoundland area and two versions of the Switlik 6-person marine life raft. In addition, leeway data for a Dunlop-Beaufort 4-person life raft collected during a prevous experiment were reanalyzed. During the course of the drift period, all leeway craft swamped or capsized.

This report summarizes statistical analyses of both the pre- and post- swamped/capsized portions of the data records. The leeway speed of the 5.5m wooden open boat decreased from 3.65 to 1.73 percent of the 10m wind speed after swamping. The leeway speed of the Switlik life raft with a full ballast bag and drogue decreased from 1.95 to 0.79 percent of the 10m wind speed after swamping. The leeway speed of the Switlik life raft with four small ballast bags and drogue decreased from 2.82 to 1.13 percent of the 10m wind speed after capsizing. The leeway speed of the Dunlop-Beaufort life raft with a drogue and four man loading decreased from 1.93 to 0.89 percent of the 10m wind speed after capsizing.


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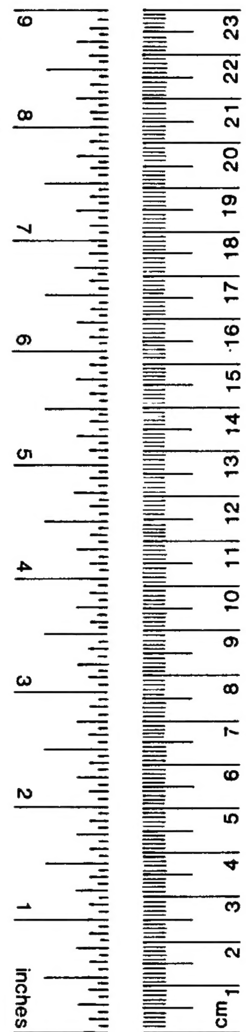
# METRIC CONVERSION FACTORS

## Approximate Conversions to Metric Measures

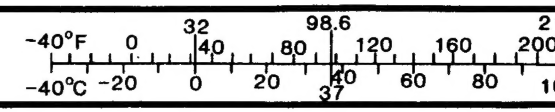
| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | *2.5 | centimeters | cm |
| ft | feet | 30 | centimeters | cm |
| yd | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 6.5 | square centimeters | $cm^2$ |
| $ft^2$ | square feet | 0.09 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.8 | square meters | $m^2$ |
| $mi^2$ | square miles | 2.6 | square kilometers | $km^2$ |
| | acres | 0.4 | hectares | ha |
| | | **MASS (WEIGHT)** | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |
| | | **VOLUME** | | |
| tsp | teaspoons | 5 | milliliters | ml |
| tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| $ft^3$ | cubic feet | 0.03 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.76 | cubic meters | $m^3$ |
| | | **TEMPERATURE (EXACT)** | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |

*1 in = 2.54 (exactly).




## Approximate Conversions from Metric Measures

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.04 | inches | in |
| cm | centimeters | 0.4 | inches | in |
| m | meters | 3.3 | feet | ft |
| m | meters | 1.1 | yards | yd |
| km | kilometers | 0.6 | miles | mi |
| | | **AREA** | | |
| $cm^2$ | square centimeters | 0.16 | square inches | $in^2$ |
| $m^2$ | square meters | 1.2 | square yards | $yd^2$ |
| $km^2$ | square kilometers | 0.4 | square miles | $mi^2$ |
| ha | hectares (10,000 $m^2$) | 2.5 | acres | |
| | | **MASS (WEIGHT)** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.2 | pounds | lb |
| t | tonnes (1000 kg) | 1.1 | short tons | |
| | | **VOLUME** | | |
| ml | milliliters | 0.03 | fluid ounces | fl oz |
| l | liters | 0.125 | cups | c |
| l | liters | 2.1 | pints | pt |
| l | liters | 1.06 | quarts | qt |
| l | liters | 0.26 | gallons | gal |
| $m^3$ | cubic meters | 35 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.3 | cubic yards | $yd^3$ |
| | | **TEMPERATURE (EXACT)** | | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |



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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| Abs | Absolute Value |
| AES | Canadian Atmospheric and Environment Service |
| CCGS | Canadian Coast Guard Ship |
| CASP | Computer Assisted Search Planning program |
| cm/s | centimeters per second |
| CODE | Coastal Ocean Dynamics Experiment |
| **CWL** [1] | Crosswind Component of the Leeway Vector (cm/s) |
| **DWL** | Downwind Component of the Leeway Vector (cm/s) |
| DEC | December |
| EMCM | Electromagnetic Current Meter |
| GPS | (NavStar) Global Positioning System |
| Hgt | Height |
| HH | Hour format (00-23) |
| hh:mm | Hours:Minutes |
| ISARC | Improvement to Search and Rescue Capabilities project |
| km | Kilometers |
| **L** | Leeway Vector (cm/s) |
| LKP | Last Known Position |
| m | Meters |
| m/s | Meters per second |
| min | Minute |
| MM | Minute format (00-59) |
| n | Number of points used in a regression |
| N/A | Not available or Not applicable |
| Neg. | Negative |
| NOV | November |
| NST | Newfoundland Standard Time |
| Pos. | Positive |
| R&DC | Research and Development Center |
| $r^2$ | Coefficient of determination |
| RDF | Radio Direction Finder |
| SAR | Search and Rescue |
| SLDMB | Self-Locating Datum Marker Buoy |
| SS | Second format (00-59) |
| $S_{s/x}$ | Standard Error of the Estimate |
| Std. Config. | Standard Configuration |
| std. dev. | Standard Deviation |
| USCG | United States Coast Guard |
| USCGC | United States Coast Guard Cutter |
| UTC | Universal Coordinate Time |
| $\mathbf{W}_{10m}$ | Wind Speed Vector Adjusted to 10 meter height |
| [1] | Vector quantities are in bold type. |

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## EXECUTIVE SUMMARY

### INTRODUCTION

Since 1991, both the United States and Canadian Coast Guards have been investigating the leeway of common Search and Rescue (SAR) objects under the terms of Joint Research Project Agreement #5. The data analyzed in this report were obtained during a joint Canada - US leeway experiment conducted off the coast of Newfoundland in November - December 1995. This experiment is the third in a series of joint field trials conducted by the U.S. Coast Guard Research and Development Center (R&DC) in conjunction with the Canadian Coast Guard and their contractor Oceans Limited, of St. John's, Newfoundland. The SAR craft investigated included a 5.5m wooden-planked open boat and two variations of Switlik 6-person life rafts.

During this study, leeway data were collected on survivor craft at higher wind speeds (up to 22.2 m/s) and higher wave conditions (significant waves up to 9.3 meters) than during previous studies. For each craft a single leeway drift run lasting from 118 to 166 hours was conducted.

The open boat and the two life rafts either swamped or capsized during the leeway drift runs. Leeway data were successfully recovered from the swamped and capsized portions of these three leeway runs as well as from an early leeway run of a Beaufort 4-person life raft during December 1992. The data records were separated into two portions, a pre-swamping or capsizing portion and a post-event portion. This report summarizes a statistical analysis of these data. The on scene environmental conditions were analyzed in order to provide guidance for the prediction of swamping and capsizing of open boats and 4-6 person life rafts.

Leeway is defined in the National SAR Manual as "movement of a craft through the water caused by wind acting on the exposed surface of the craft." Fitzgerald et al. (1993) proposed a revised leeway definition:

> "Leeway is the velocity vector of a SAR object relative to the downwind direction of the search object as it moves relative to the surface current (measured between 0.3m and 1.0m depth) caused by winds (adjusted to a reference height of 10m) and waves."

Results of this report are presented using this revised definition of leeway. The wind vectors adjusted to the 10 meter reference height are referred to in this report as $\mathbf{W}_{10m}$.

The direct method, first used by Fitzgerald et al. (1993), was used to measure leeway in this experiment. An InterOcean S4® electromagnetic current meter (EMCM) was tethered to the SAR object to measure velocity relative to the water. Winds, surface currents, and total displacement of the SAR craft were also measured.

RESULTS

Leeway Rate

This study was conducted on a 5.5m wooden-planked open boat common to the Newfoundland region and two 4-6 person maritime life rafts manufactured by Switlik. An additional leeway drift run from December 1992, involving a Beaufort 5-sided 4-person life raft, was analyzed to evaluate the capsized portion of its run. The 5.5m open boat swamped during its run. One of the Switlik life rafts swamped and the other Switlik life raft capsized.

**The leeway rates of three life rafts and a small boat after swamping or capsizing were 40 to 47 percent of the leeway rate for the same craft in their standard configurations, as shown in Table ES-1. This represented significant reduction in the leeway speed of each of these search targets.**

Table ES-1
Summary of Mean Leeway Rates

| Leeway Craft | Orientation | Mean Leeway Rate (percent of $\mathbf{W}_{10m}$) | Mean Leeway Rate of Swamped/Capsized Craft as a Percent of the Std. Configuration Rate |
|---|---|---|---|
| 5.5m wooden-plank open boat | Std. Configuration | 3.65 | 47% |
| | Swamped | 1.73 | |
| Switlik 6-Person life raft "J" full toroidal bag | Std. Configuration | 1.95 | 41% |
| | Swamped | 0.79 | |
| Switlik 6-Person life raft "H" 4 small ballast bags | Std. Configuration | 2.82 | 40% |
| | Capsized | 1.13 | |
| Beaufort 5-sided 4-person life raft | Std. Configuration | 1.93 | 46% |
| | Capsized | 0.89 | |

Probability of Swamping and Capsizing Events

The 1995 field experiment added three documented and two undocumented instances of swamping, capsizing, or sinking to the list of such events occurring in 1992 and 1993. A list of significant events from the three field experiments is provided in Table ES-2. This table provides a start for developing probabilities of occurrence for swamping and capsizing events.

Table ES-2
Summary of 1992, 1993 and 1995 Swamping, Capsizing and Sinking Events

| Leeway Craft | Leeway Run # | Event | Time of Event (UTC) | Hours after Deployment | 10m Winds (m/s) | Wave Height (m) |
|---|---|---|---|---|---|---|
| Beaufort life raft 4-person loading, drogue | 22 | Capsized | 07:00 6 DEC 92 | 81 | 17.2 | 4.3 |
| Tulmar life raft 4-person loading, drogue | 25 | Capsized | 00:10 13 DEC 92 | 57 | 13 | 5 |
| L1011 Aircraft Slide Raft | 51 | Sunk | 08:20 11 DEC 93 | 15 | 8 | 3 - 3.5 |
| Beaufort life raft 1-person loading, no drogue | 54 | Capsized | 21:00 16 DEC 93 | 27 | 15 | 5 - 6 |
| 5.5m open boat #1 | 60 | Swamped | 22:50 28 NOV 95 | 56 | 16.2 | 3.4 - 3.9 |
| 5.2m open boat #2 | 61 | Assumed Sunk | NOV 95 | unknown | N/A | N/A |
| 5m open boat #3 | 62 | Assumed Sunk | after 14:51 30 NOV 95 | $\geq$ 115 | 7.5 | 4.5 |
| Switlik 6-person life raft "J" full toroidal ballast bag | 63 | Swamped | 22:30 28 NOV 95 | 55.5 | 16.1 | 3.5 |
| Switlik 6-person life raft "H" 4 small ballast bags | 64 | Capsized | 18:50 2 DEC 95 | 47.5 | 16.7 | 5.6 - 5.9 |

## RECOMMENDATIONS AND CONCLUSIONS

### Leeway Inputs for Manual Search Planning Methods

Two simple statistical models of leeway speed and angle for the four craft in the standard and swamped/capsized configurations are recommended in Chapter 5. These models are for incorporation into manual search planning methods and for "User Defined Leeway" input to the present version of the Computer Aided Search Planning (CASP) program. Both statistical models are based upon: (1) a constrained linear function of leeway speed on wind speed; (2) an uncertainty of the leeway speed based upon the standard error; (3) twice the standard deviation of the leeway angle about the downwind direction, and (4) the mean leeway angle. When the constrained linear function was not statistically valid, the mean leeway rate and twice

the standard deviation of the leeway rate were substituted into the simple leeway model. These models apply when winds are less than 20m/s (40 knots).

Leeway Inputs for Numerical Search Planning Tools

Unconstrained linear regression statistical models of the downwind and crosswind components of leeway and their 95% prediction limits are recommended for implementation in computerized numerical search planning models. This report presents results for the standard configurations of a 5.5m wooden-planked open boat and a drogued Switlik 6-Person life raft with canopy and full toroidal ballast bags.

Prediction of Swamping and Capsizing Events

This research demonstrated that the leeway speed of swamped or capsized life rafts and small boats is substantially less than that for those same craft in their normal or standard configuration. The leeway information presently available in CASP and the SAR Manual is based on studies conducted during moderate wind conditions. The current SAR Manual guidance is to use the leeway equations provided for wind up to 40 knots (20.5 m/s) to predict the leeway of life rafts and other craft. In heavy weather, life rafts and small boats may swamp, capsize or sink. Under these circumstances, direct application of the leeway equations in CASP and the SAR Manual would greatly **over-estimate** the drift of those survivor craft that swamp or capsize.

For search planning purposes a means of predicting the swamping or capsizing of maritime survivor craft is essential to properly account for observed reduction in leeway speed. That the swamping and capsizing events are not a simple function of wind speed or wave height suggests that this is an area that will require further investigation to determine which environmental factors or combinations of factors directly affect life raft and small craft stability and sea-worthiness. The goal should be to determine which readily-available environmental data product(s) can be used to accurately predict the conditions when life rafts and small craft change phase from a standard configuration leeway target to a swamped or capsized leeway target.

## SOMMAIRE

INTRODUCTION

Depuis 1991, les Gardes côtières canadienne et américaine ont étudié la dérive dûe au vent sur des objets de Recherche et Sauvetage (SAR) communs sous les termes de l'Entente #5 d'un Projet de Recherche Mixte. Les données analysées dans ce rapport ont été obtenues lors d'une expérimentation combinée entre le Canada et les États-Unis au large de la côte de Terre-Neuve en novembre-décembre 1995. Cette expérimentation est la troisième d'une série d'essai menée en mer par le "U.S. Coast Guard Research and Development Center (R&DC)" conjointement avec la Garde côtière canadienne et leur entrepreneur "Oceans Limited" de Saint-Jean Terre-Neuve. L'équipement SAR étudié comprenait une embarcation ouverte de 5.5m en madrier de bois et deux differents radeaux de sauvetage à 6 places Switlik.

Au cours de cette étude, les données de dérive ont été collectionnées pour des embarcations de sauvetage à des vitesses de vent plus élevés (jusqu'à 22.2 m/s) et des conditions de houle plus élevées (des vagues allant jusqu'à 9.3 mètres) que pendant les études antécédentes. Chaque embarcation a dérivé pendant une période variant entre 118-166 heures.

L'embarcation ouverte et les deux radeaux de sauvetage ont soit submergé ou chaviré durant les essais pour mesurer la dérive dûe au vent. Les données de dérive ont été récupérées avec succès des étapes de ces trois essais ainsi que pour un essai préliminaire sur un radeau de sauvetage Beaufort à 4 places en Décembre 1992. Les données obtenues durant ces essais ont été séparé en 2 portions; une portion pré-submergement ou chavirement et une portion post - événement. Ce rapport résume sommairement les analyses statistiques de ces données. Les conditions environnementales sur place ont été analysées afin de servir de guide pour la prédiction de submergement et de chavirement d'embarcations ouvertes et de radeaux de sauvetage de 4-6 places.

La dérive est définie dans le "National SAR Manual" comme étant le "mouvement d'une embarcation sur l'eau causé par le vent agissant sur la surface exposée de l'embarcation". Fitzgerald et al. (1993) ont proposé une révision de la définition de dérive:

> "La dérive est le vecteur de vélocité d'un objet de SAR ayant comme direction la direction sous le vent prévalant vent arrière et comme vitesse la vitesse du courant de surface (mesuré entre 0.3m et 1.0m de profondeur) causé par les vents (ajustés à une hauteur de référence de 10m) et par la houle".

Les résultats de ce rapport utilisent cette définition révisée de la dérive. À l'intérieur de ce rapport on utilise le terme $\mathbf{W}_{10m}$ pour référer aux vecteurs de vent ajustés à une hauteur de référence de 10 mètres.

La méthode directe utilisée premièrement par Fitzgerald et al. (1993) a été utilisée pour mesurer la dérive dans cette expérimentation. Un "Inter Ocean S4 electromagnetic current meter (EMCM)" a été attaché à l'objet de recherche et sauvetage pour mesurer la vélocité relative à l'eau. Les vents, courants de surface et déplacement total de l'embarcation de recherche ont aussi été mesurés.

## RÉSULTATS

### Le Rapport entre la Vitesse de Dérive et la Vitesse du Vent

L'étude a été effectuée sur une embarcation ouverte de 5.5 mètres en madrier de bois d'usage courant dans la région de Terre-Neuve et deux radeaux de sauvetage marins de 4-6 places manufacturés par Switlik. Les données d'essais qui ont eu lieu en décembre 1992 impliquant un radeau de sauvetage Beaufort à 5 côtés, 4 places entraîné à la dérive ont été analysées de nouveau pour évaluer la portion de chavirement de ces essais. Au cours de cet essai l'embarcation ouverte de 5.5m a submergée, un des radeaux de sauvetage Switlik a submergé et l'autre a chaviré.

**Lorsque les radeaux de sauvetage et petite embarcation ont été submergés ou chavirés leur degré de dérive est tombé à 40 à 47 pourcent de leur valeur originale comme démontré dans le tableau ES-1. Ceci a représenté une réduction significative dans la vitesse de dérive de chacune de ces objets de recherche.**

Tableau ES-1
Sommaire des Rapports Moyens entre la Vitesse de Dérive et la Vitesse du Vent

| Embarcation à la dérive | Orientation | Rapport Moyen (Pourcentage de $\mathbf{W}_{10m}$) | Rapport Moyen comme Pourcentage de la Configuration Type |
|---|---|---|---|
| Embarcation ouverte de 5.5m en madrier de bois | Configuration Type | 3.65 | 47% |
| | Submergé | 1.73 | |
| Radeau de sauvetage "J" Switlik à 6places avec sac toroïdal plein | Configuration Type | 1.95 | 41% |
| | Submergé | 0.79 | |
| Radeau de sauvetage "H" Switlik à 6 places avec 4 sacs de ballast | Configuration Type | 2.82 | 40% |
| | Chaviré | 1.13 | |
| Un radeau de sauvetage Beaufort à 5 côtés et 4 places | Configuration Type | 1.93 | 46% |
| | Chaviré | 0.89 | |

Probabilité d'Occurrences de Submergement et de Chavirement

L'expérimentation en mer de 1995 s'ajoute à la liste de résultats obtenus en 1992 et 1993, trois cas documentés et deux cas non documentés de submergement, chavirement ou engloutissement. Une liste de graves incidents survenus durant les trois expérimentations en mer sont résumés sommairement au Tableau ES-2. Ce tableau fourni des données pour entamer une étude pour savoir quand les incidents de submergement ou de chavirement pourront probablement se produire.

Tableau ES-2
Sommaire des Occurences de Submergement, Chavirement et Engloutissement en 1992,1993 et 1995

| Embarcation à la derive | # parcours de la dérive | Occurrence | Temps de l'occurence | Heures après déploiement | Vents 10m (m/s) | Hauteurs des vagues (m) |
|---|---|---|---|---|---|---|
| Radeau de sauvetage Beaufort avec une charge de 4 personnes, ancre flottante | 22 | chaviré | 07:00 6 DEC 92 | 81 | 17.2 | 4.3 |
| Radeau de sauvetage Tulmar avec une charge de 4 personnes, ancre flottante | 25 | chaviré | 00:10 13 DEC 92 | 57 | 13 | 5 |
| Avion à glissière-radeau L1011 | 51 | coulé | 08:20 11 DEC 93 | 15 | 8 | 3-35 |
| Radeau de sauvetage Beaufort avec une charge d'une place, sans ancre flottante | 54 | chaviré | 21:00 16 DEC 93 | 27 | 15 | 5-6 |
| Embarcation ouverte #1 5.5m | 60 | submergé | 22:50 28 NOV 95 | 56 | 16.2 | 3.4 - 3.9 |
| Embarcation ouverte #2 5.2m | 61 | presumé coulé | NOV 95 | inconnu | N/A | N/A |
| Embarcation ouverte # 3 5m | 62 | presumé coulé | après 14:51 30 nov 95 | >= 115 | 7.5 | 4.5 |
| radeau de sauvetage "J" Switlik 6 places avec sac de ballast toroïdal plein | 63 | submergé | 22:30 28 NOV 95 | 55.5 | 16.1 | 3.5 |
| radeau de sauvetage "H" Switlik 6 places avec petit sac de ballast | 64 | chaviré | 18:50 2 DEC 95 | 47.5 | 16.7 | 5.6 - 5.9 |

## RECOMMENDATIONS ET CONCLUSIONS

### Information sur la Dérive pour les Méthodes de Planification de Recherches Manuelles

Deux modèles statistiques simples de vitesse et angle de dérive pour les quatre embarcations dans les configurations type et submergés/chavirées sont recommandés au Chapitre 5. Ces modèles seront incorporés aux méthodes de planification de recherche manuelle et pour information sur "User Defined Leeway" à la version présente du programme "Computer Aided Search Planning (CASP)". Les deux modèles statistiques sont basés sur: (1) une fonction linéaire constrainte de la vitesse de dérive sur la vitesse du vent; (2) une incertitude de la vitesse de dérive basée sur l'erreur type, (3) le double de la déviation type de l'angle de dérive environ la direction sous le vent et (4) l'angle de dérive moyen. Lorsque la fonction linéaire constrainte n'était pas statistiquement valide, le taux de dérive moyen et le double de la déviation type du taux de dérive ont été substitués par le modèle simple de dérive. Ces modèles s'appliquent lorsque les vents sont moins de 20m/s (40 noeuds).

### Information sur la Dérive pour des Outils de Planification de Recherches Numériques

Des modèles statistiques à régression linéaire sans constraintes composant la dérive sous le vent ainsi que pour un vent de travers et leurs limites de prédictions à 95% sont recommandés pour être implantés dans des modèles numériques de planification de recherche. Ce rapport présente des résultats de ce genre pour des configurations types d'une embarcation ouverte de 5.5m en madrier de bois et un radeau de sauvetage à 6 places Switlik ancré avec canope et sacs de ballast toroïdaux pleins.

### Prédiction des Occurrences de Submergement et de Chavirement

Cette recherche a démontré que la vitesse de dérive de radeaux de sauvetage et petites embarcations submergés ou chavirés est substantiellement moindre que celle des mêmes embarcations dans des configurations normale ou type. Les informations de dérive disponibles présentement dans CASP et "SAR Manual" sont basées sur des études conduites à des conditions de vents modérés. Le "SAR Manual" suggère d'utiliser les équations de dérive pourvu que les vents ne dépassent pas 40 noeuds (20.5 m/s) afin de prédire la dérive de radeaux de sauvetage et autres embarcations. Par gros temps, les radeaux de sauvetage et petites embarcations peuvent submerger, chavirer ou couler. Sous de telles circonstances, l'application directe des équations de dérive dans CASP et le "SAR Manual" donnerait une estimation exagérée de la dérive ces embarcations de sauvetage qui submergent ou chavirent.

Pour fins de planification, il est essentiel d'avoir une méthode pour prédire quand un chavirement ou un submergement de d'un radeau ou embarcation de sauvetage peut arriver pour justifier cette réduction substantielle du taux de dérive comme l'étude a démontré. Le fait que les occurrences de submergement et de chavirement ne soient pas une fonction simple de la vitesse du vent ou de la hauteur des vagues suggère que c'est

une région qui demande de plus recherches afin de déterminer quels facteurs environnementaux ou combinaisons de facteurs affectent directement la stabilité et navigabilité de radeaux de sauvetage et petites embarcations. Le but d'un projet de recherche devrait être de déterminer quels données environnementales faciles d'accès peuvent être utilisés correctement pour prédire les conditions lorsque les radeaux de sauvetages et petites embarcations passent d'une cible à la dérive de configuration type à une cible à la dérive submergée ou chavirée.

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# CHAPTER 1

# INTRODUCTION

## 1.1 SCOPE

The 1995 Leeway Experiment was a joint experiment by the U.S. Coast Guard Research and Development Center (R&DC), the Canadian Coast Guard and their contractor Oceans Limited of St. John's Newfoundland. The experiment was conducted on the Grand Banks of Newfoundland off St. John's, Newfoundland, from 25 November to 1 December 1995. The direct method (defined in Chapter 2) of measuring leeway was used during this experiment. The objective of this experiment was to determine the leeway rates and divergences used in drift prediction for search and rescue (SAR) mission planning. Results of this work are expected to be used to update SAR planning guidance material provided in the National Search and Rescue Manual (1991) and in CASP (Computer Assisted Search Planning) computer models.

This was the third joint US/Canadian Leeway Experiment that was conducted on the Grand Banks during the autumn. The results of the 1992 experiment were reported by Fitzgerald, Finlayson, Cross, and Allen. (1993) and the 1993 experiment results were reported by Fitzgerald, Finlayson, and Allen (1994). The leeway targets used in first two experiments are listed in Table 1-1.

Table 1-1
Leeway Targets Tested During the 1992 and 1993
US/Canadian Leeway Field Experiments

| TARGET DESCRIPTION | LOADING | DROGUE | |
|---|---|---|---|
| | | WITH | WITHOUT |
| Beaufort 5-sided 4-person life raft | 1 person | No | Yes |
| Beaufort 5-sided 4-person life raft | 4 persons | Yes | Yes |
| Beaufort 6-sided 4-person life raft | 1 person | No | Yes |
| Beaufort circular 20-person life raft | 4 persons | No | Yes |
| Beaufort circular 20-person life raft | 20 persons | Yes | No |
| 5.6 m Open plank boat | 2-3 persons | No | Yes |
| SOLAS approved 22-person life capsule | 12 persons | No | Yes |
| L1011 aircraft evacuation slide / 46-person raft | 20 persons | No | Yes |
| USCG Sea Rescue Kit | 0 person | Yes | No |
| Tulmar 4-person life raft | 4 persons | Yes | Yes |
| Tulmar 4-person life raft | 1 person | Yes | Yes |

Fitzgerald et al. (1994) summarizes three capsizings and one sinking of life rafts during the 1992 and 1993 autumnal leeway experiments on the Grand Banks of Newfoundland. The four events as reported by Fitzgerald et al. (1994) are summarized in Table 1-2.

Table 1-2
Summary of 1992 and 1993 Capsizing and Sinking of Leeway Targets from Fitzgerald et al. (1994)

| Leeway Craft | Leeway Run # | Event | Time of Event (UTC) | Hours after Deployment | 10m Winds (m/s) | Wave Height (m) |
|---|---|---|---|---|---|---|
| Beaufort life raft 4-person loading, drogue | 22 | Capsized | 19:40 5 DEC 92 | 83 | 21 | 5 - 6 |
| Tulmar life raft 4-person loading, drogue | 25 | Capsized | 00:10 13 DEC 92 | 57 | 13 | 5 |
| L1011 Aircraft Slide Raft | 51 | Sunk | 08:20 11 DEC 93 | 15 | 8 | 3 - 3.5 |
| Beaufort life raft 1-person loading, no drogue | 54 | Capsized | 21:00 16 DEC 93 | 27 | 15 | 5 - 6 |

During the 1995 experiment, leeway data were collected on three craft: a 5.5m open wooden-planked boat, and two life rafts. An additional two open wooden-planked boats were outfitted and deployed for leeway data collection, but were never recovered due to the heavy weather encountered during this experiment. The weather encountered during the 1995 experiment was heavier than during the 1992 and 1993 experiments. Thus, the data set available for analysis was limited to three of the five craft deployed during 1995 plus one additional life raft that capsized, during the 1992 experiment. The data record from a Beaufort 5-sided 4-person life raft, Leeway Run 22, was re-analyzed using the wind record from the adjacent leeway target of Leeway Run 23. This was the only leeway drift run from the 1992 and 1993 field experiments for which a wind record was available when the craft capsized.

This report presents the results of the joint U.S. and Canadian field experiment conducted under the terms of Joint Research Project Agreement #5 between the two Coast Guards. The Canadian Coast Guard's contractor, Oceans Limited of St. John's, Newfoundland, conducted the field experiment with assistance from the Canadian Coast Guard and U.S. Coast Guard Research and Development Center (R&DC). The R&DC analyzed the leeway data from the experiment for this report. R&DC participated in the experiment under project element 1012.3.7, Leeway of Small SAR Objects, in the Improvements to Search and Rescue Capabilities (ISARC) project.

Chapter 1 is a review of the methods used in previous leeway experiments for measuring leeway, currents, and winds. The methods and leeway craft used during this experiment are

described in Chapter 2. A summary of data reduction and a review of the statistical methods used are presented in Chapter 3. Statistical models for leeway craft behavior are presented in Chapter 4. Chapter 5 contains recommendations, conclusions and suggestions for future work in this area.

## 1.2 BACKGROUND

A key element of a successful search is the accurate prediction of the total displacement of a SAR target from its estimated Last Known Position (LKP). For a search object located on the surface of the water, the total displacement is the vector addition of the sea surface currents and leeway.

For the search planner using manual methods, the components of leeway include leeway speed and leeway angle. Leeway speed is the speed at which the wind will push an object through the water. Leeway angle is the angle off the downwind direction which the object sailed. Expressing leeway in terms of its downwind and crosswind components, instead of leeway speed and leeway angle, has advantages for interpretation of behavior and for ease of incorporation into the numerical models.

Leeway as defined by the National SAR Manual is "that movement of a craft through the water, caused by the wind acting on the exposed surface of the craft." This definition of leeway is physically correct, but has two major operational shortcomings. Objects on the surface of the ocean are at the interface of two boundary layers where there is high vertical shear in the velocity profiles of wind and sea currents. Fitzgerald et al. (1993) proposed a revised leeway definition:

> "Leeway is the velocity vector of the search object relative to the downwind direction at the search object as it moves relative to the surface current as measured between 0.3m and 1.0m depth caused by winds (adjusted to a reference height of 10m) and waves".

This operational definition of leeway was used for presenting the results of this report.

This definition standardizes the reference levels for the measurement of the leeway of SAR objects. Both of these levels are readily available to the operational SAR planner. Most "sea level" wind products are adjusted to the 10 meter height. The new Self-Locating Datum Marker Buoys (SLDMBs) are designed with drag elements between 0.3 m and 1.0 m depth.

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# CHAPTER 2

## THE EXPERIMENT

### 2.1 DESIGN AND CONDUCT

This field experiment was conducted on the Grand Banks of Newfoundland, between 25 November and 1 December 1995. Leeway was directly measured using a tethered current meter. The leeway drift runs were started near a moored meteorological buoy which measured winds and wave height. Additional wind measurements were collected aboard the leeway targets. Two types of surface current measurements were made. A current meter was attached to the float line of the meteorological buoy to provide Eulerian surface current information. A surface drifter was also released in the experiment area to provide Lagrangian estimates of surface currents. GPS data loggers were used to measure total displacement of the leeway craft. Transmitting Argos and RDF beacons were aboard each craft to aid in its recovery.

#### 2.1.1 Measurement of Leeway

Fitzgerald et al. (1993) was the first to used the direct method for measuring leeway. The direct method uses a current meter attached to a search object to measure the relative motion of that search object through the water at the depth of the current meter. Fitzgerald et al. (1993) validated the direct method in a direct comparison with the older traditional indirect method where the velocity estimates from surface drifters are subtracted from the velocity estimates of the search object over the ground to obtain estimates of the search object through the water. The direct method was used to measure leeway in this experiment. An InterOcean S4® electromagnetic current meter (EMCM) was tethered to the SAR object to measure velocity relative to the water. The S4® EMCMs were suspended with a stainless steel frame at 0.75 meter depth, thus the water reference level for this report is 75 centimeters. The frame was attached to a float sized to nearly match the wind induced drift of the leeway craft. This method minimizes the drag on the leeway craft imposed by the current meter (see, Fitzgerald et al. (1993) , Appendix C). The frame with S4® EMCM was attached by a 15 meter line to the pivot point of the leeway craft to minimize steering effects of the attached current meter on the search object.

The InterOcean S4® EMCMs sampled at 2 Hz, and were vector averaged over 10 minute periods. An internal flux-gate compass converted the two orthogonal components of velocity to magnetic north and east coordinates. The raw directions of currents from the S4® EMCM were adjusted for the magnetic variation (-22.545 degrees) and then rotated 180 degrees. Two tilt sensors in the S4® EMCM were used to apply, at 2 Hz, the cosine correction for the tilt angle to the current speed. Temperature at 0.75 meter depth was also sampled every 10 minutes. The S4® EMCMs were calibrated yearly by InterOcean.

2.1.2 Measurement of Wind

The standard method for measuring wind during this experiment uses onboard wind monitoring systems calibrated to a moored Coastal Climate MiniMet® buoy (see Fitzgerald et al. (1993) and (1994) and Allen (1996a). During this experiment the leeway craft were equipped with R.M. Young anemometers. However, none of these onboard systems survived. As a result, all wind data used in this analysis was from the R.M. Young anemometer on the Coastal Climate MiniMet® buoy which was moored in the center of the experiment area. The MiniMet® buoy's R.M. Young anemometer was mounted at a 3 meter height. The MiniMet® buoy sampled at 1 Hz for 10 minutes. The MiniMet® Buoy also sampled the following every 10-minutes on a continuous cycle:

YY:MM::DD HH:MM time at end of sampling period
10-minute vector average of wind speed
10- minute vector average of wind direction (magnetic from)
10- minute vector average vane bearing
10- minute vector average compass heading
10-minute scalar average wind speed
5-second wind maximum (gust)
Seconds from start of the 10-minute sample of the gust
Water temperature at 2 meter depth
Internal buoy temperature
Air temperature at 3 meter height
Latitude from the GPS receiver
Longitude from the GPS receiver
Barometric pressure at 3 meter height
Buoy battery voltage
Checksum

The MiniMet® buoy wave data included significant wave height and wave energy spectrum from a Datawell® gimbaled heave sensor. Wave height was sampled at 1 Hz for 512 seconds every 20 minutes.

R.M. Young anemometers were calibrated prior to the field testing for both speed and relative bearing. The compasses in the Weatherpaks® and the MiniMet® were also calibrated to determine deviations. The anemometers were then paired with a Weatherpak® or the MiniMet® buoy to minimize error as a function of heading. A second calibration was conducted of the anemometer - A/D converter system. The MiniMet® compass deviation corrections were applied at the 1 Hz sampling interval. Instrument error for wind direction from the MiniMet® wind monitoring system was estimated to be $\pm 2^{\circ}$.

The MiniMet® buoy winds were checked against the Canadian Atmospheric and Environment Service (AES) analysis winds at 10-meters for 00 UTC and 12 UTC. Wind Speed adjusted to 10m height from the MiniMet® buoy agrees with the AES winds through the entire record; see figure 2-1 (A). However, wind direction from the MiniMet® buoy fails to agree with the AES wind direction after yearday 331 12:15 UTC; see figure 2-1 (B).

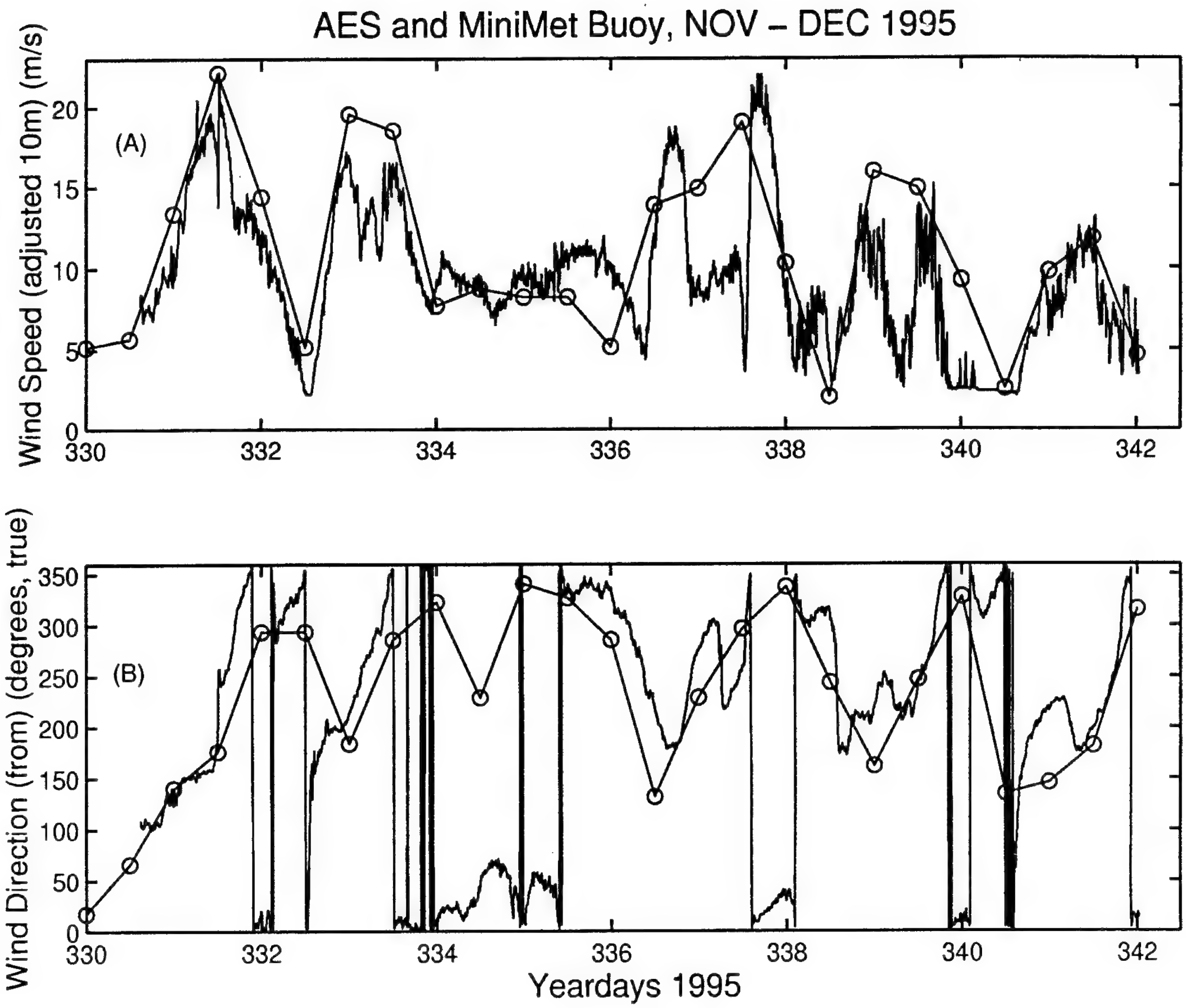


Figure 2-1. Time Series of Wind Speed Adjusted to 10m height (A) and Wind Direction (B) from MiniMet® buoy and from 12 hourly AES analysis (circles).

### 2.1.3 Measurement of Drift

On board each leeway craft was a six channel Trimble Global Positioning System (GPS) receiver and data logger. The GPS position and time were stored at 5 minute intervals by a Tattletale® data logger. The GPS receiver, data logger and batteries were housed in a waterproof case. The GPS antenna was mounted on board the leeway craft and connected through a watertight bulkhead connection in the waterproof case to the GPS receiver.

GPS positions during the experiment period had an accuracy of better than 100 meters 97 percent of the time.

### 2.1.4 Measurement of Sea Surface Currents

Two methods of measuring the sea surface currents were used. Eulerian currents were measured by a S4® EMCM attached to MiniMet's® surface float line, at 0.75 meter depth. Lagrangian currents were measured by the deployment of a surface drifter during the first group of leeway craft deployments.

An S4® EMCM was attached to the float line of the MiniMet® buoy. This position in the float line isolated the S4® EMCM from the mooring line strumming interference and influence of the MiniMet® buoy hull. The float line follows the surface waves that have periods greater than 4 seconds. The S4® EMCM sampled at 2 Hz, and was averaged over 10 minute periods continuously. A cosine correction for tilt was applied to the horizontal currents using the two vertical tilt sensors. Sea surface temperature at 0.75 meter depth was sampled every 10 minutes. The horizontal currents were corrected for the horizontal motion of the MiniMet® about its anchor.

A surface drifter was deployed at the beginning of the first group of leeway runs. This surface drifter, (Figure 2-2), was a 7/10$^{th}$ scaled version of the Coastal Ocean Dynamics Experiment (CODE) drifter developed by Davis (1985). The 7/10$^{th}$ CODE drifter had drag vanes that spanned the depth range 0.3 to 1.0 meters. The drifter was positioned at 30 minute intervals by on board GPS receiver. The surface drifter GPS positions were telemetered through the Argos System. The purpose of the drifter experiment was to investigate the performance of GPS/Argos SLDMBs in heavy weather, (see Allen (1996b) for results). The drift error for this drifter was assumed to be the GPS positional error which was less than 130 meters 95 percent of the time.

### 2.1.5 Craft Recovery System

Aboard the leeway targets were Argos and RDF transmitters. Argos positions were provided through the Argos System. For local relocation, a Gonio® 400 Radio Direction Finder (RDF,) tuned to the Argos System frequency (401.065 Mhz) along with the ship RDF were used to direct the Canadian Coast Guard Ship (CCGS) SIR HUMPHREY GILBERT to the leeway craft.

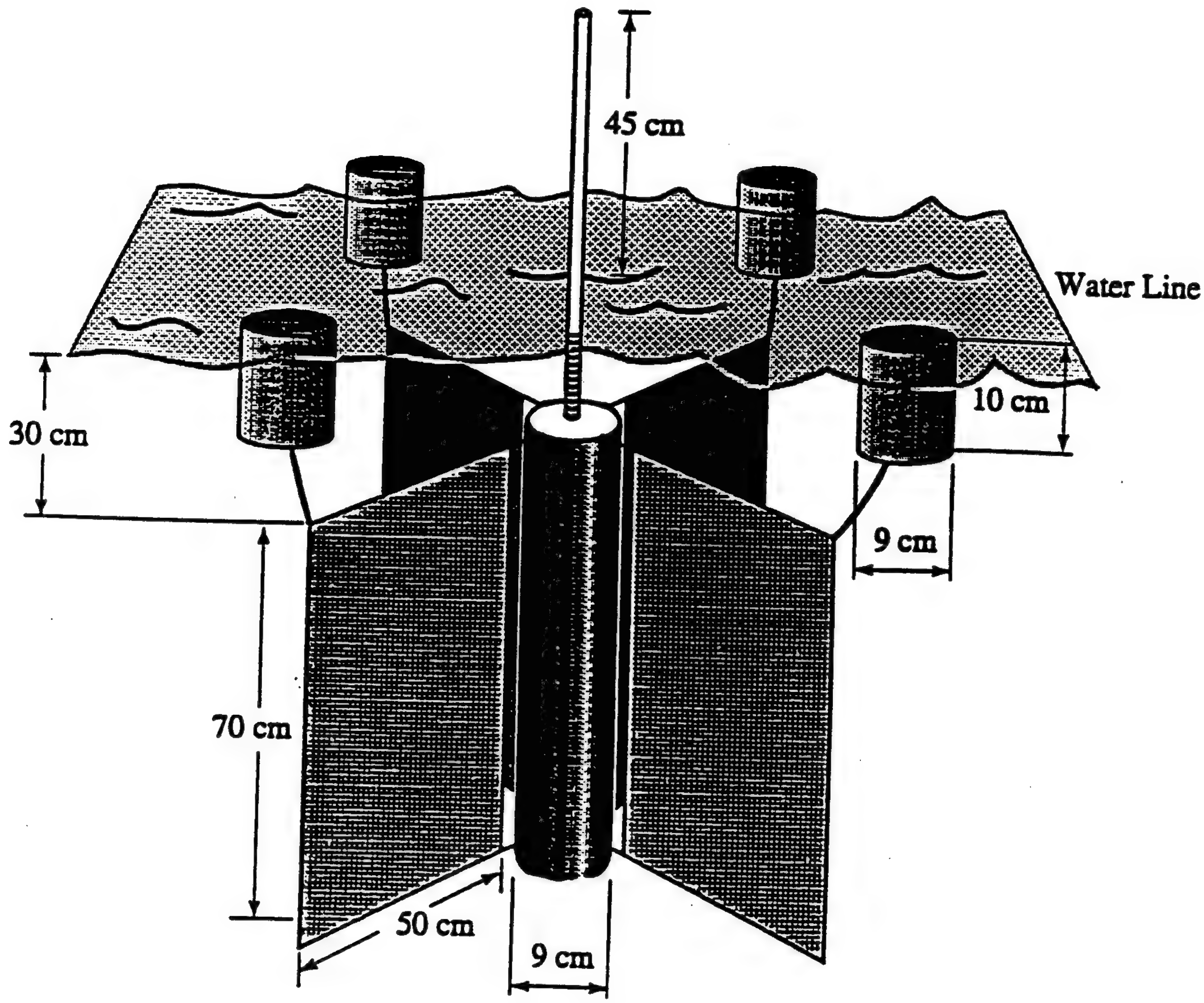


Figure 2-2. The 7/10$^{th}$ CODE Drifter in the Deployed Configuration

## 2.2 TEST CRAFT

### 2.2.1 Open Wooden-Planked Boats

Three open wooden-planked boats common to the Newfoundland region were outfitted for this leeway study. These boats were designated as #1, #2 and #3. All three boats were deployed, but only one boat (#1) was recovered. The boat that was recovered was the same boat studied by Fitzgerald et al. (1993) and (1994). Figure 2-3 shows the dimensions of Boat #1. Boat #1 was loaded only with experiment related equipment. The boats contained a GPS positioning system, a leeway measuring system, Argos and RDF beacons, and a radar reflector. The anemometer height was 2.79 meters above the water line. The S4® EMCM in a frame suspended from a float was tethered to a bridle that was suspended underneath the hull of the boat to allow for full rotation and pivoting of the current meter about the boat. The typical loading of this type of craft off Newfoundland is one or two persons. Total weight of boat and gear was 695 kilograms (1530 pounds). An outboard motor was attached to the rear transom. The open boats were decked over to prevent swamping. A covered hatch just aft of the anemometer mast provided access to the data loggers and batteries. All equipment was tied down.

### 2.2.2 Switlik 6-person Life Raft "J" with Full Toroidal Ballast Bag

Life raft "J" was an eight-sided maritime life raft with a full toroidal ballast bag. This raft was from the USCG Sea Rescue Kit., as shown in Figure 2-4. This raft was outfitted with a wind monitor system, a GPS data logger, Argos and RDF beacons. A S4®EMCM in a frame suspended from a float was tethered to the drogue attachment point. Attached to S4 frame with 15 meters of line was a drogue. The R.M. Young anemometer was at a height of 1.83 meters above the water line. The loading onboard the life raft was equivalent to 1-person.

### 2.2.3 Switlik 6-person Life Raft "H" with Four Small Ballast Bags

Life raft "H" was a modified, rectangular Switlik life raft with four small ballast bags, as shown in Figure 2-5. This raft was outfitted with a wind monitor system, a GPS data logger, and Argos and RDF beacons. The RM. Young anemometer was at a height of 1.75 meters above the water line. A S4®EMCM in a frame suspended from a float was tethered to the drogue attachment point. Attached to the S4 frame with 15 meters of line was a drogue. The loading onboard the life raft was equivalent to 1-person.

This life raft was previously studied by Fitzgerald (1995) during a leeway field experiment off Nova Scotia during fall of 1994. The outfitting of life raft "H" during the 1994 study, including loading and presence of a drogue, was equivalent to the 1995 study. The preliminary results are presented in Fitzgerald (1995) and the data from the 1994 experiment are incorporated into this report in section 4.4.2.

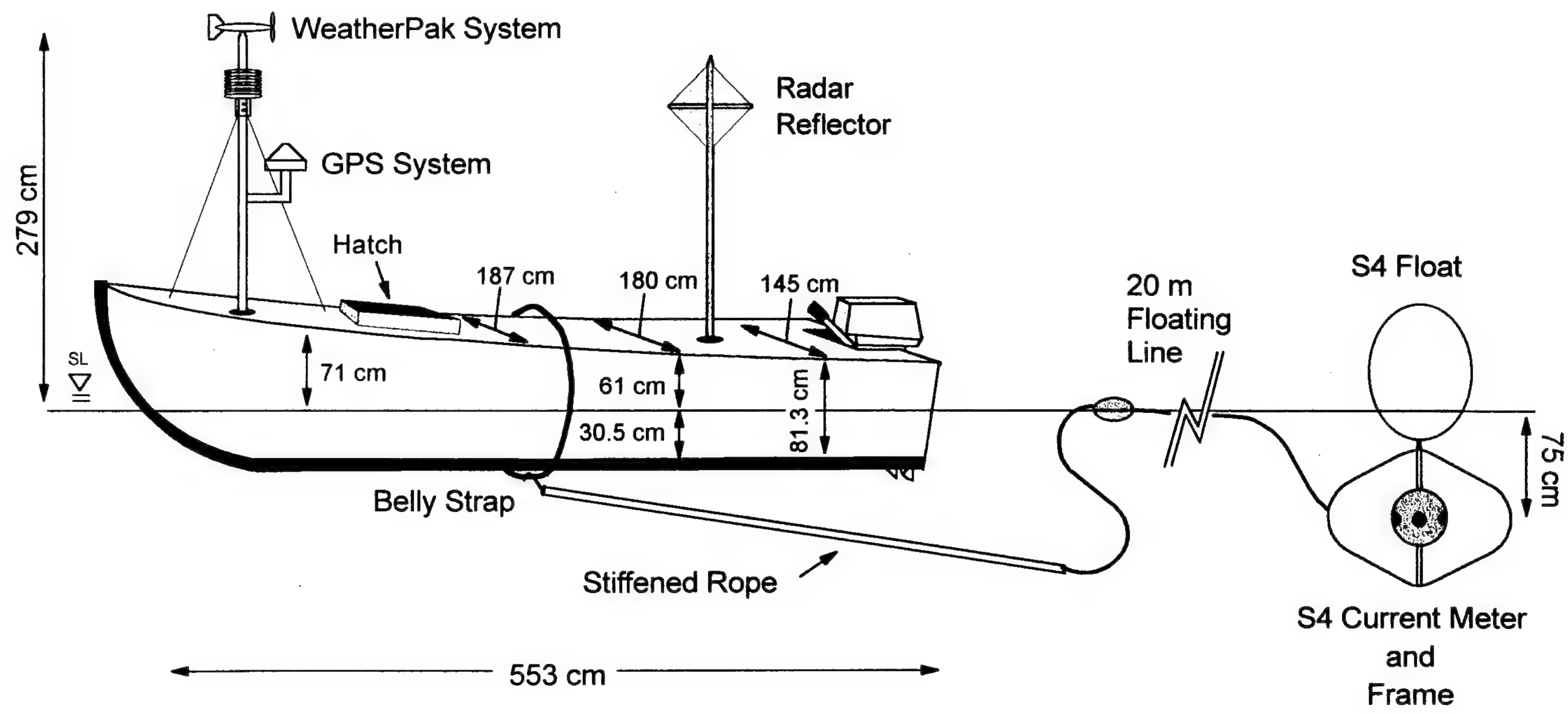


Figure 2-3. The 5.5m Wooden-Planked Open Boat #1

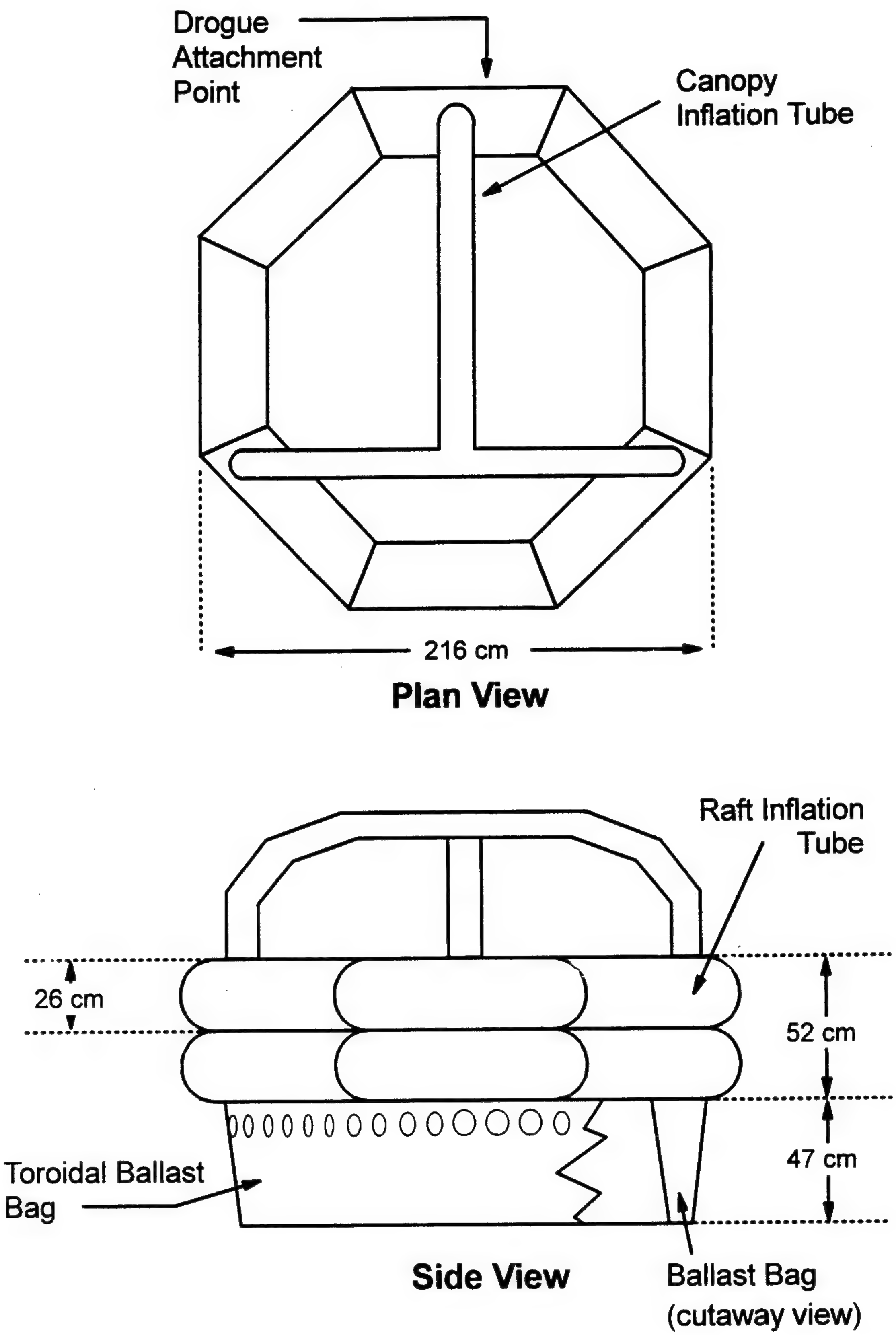


Figure 2-4. The Switlik 6-Person 8-Sided Life Raft "J" with Full Toroidal Ballast Bag

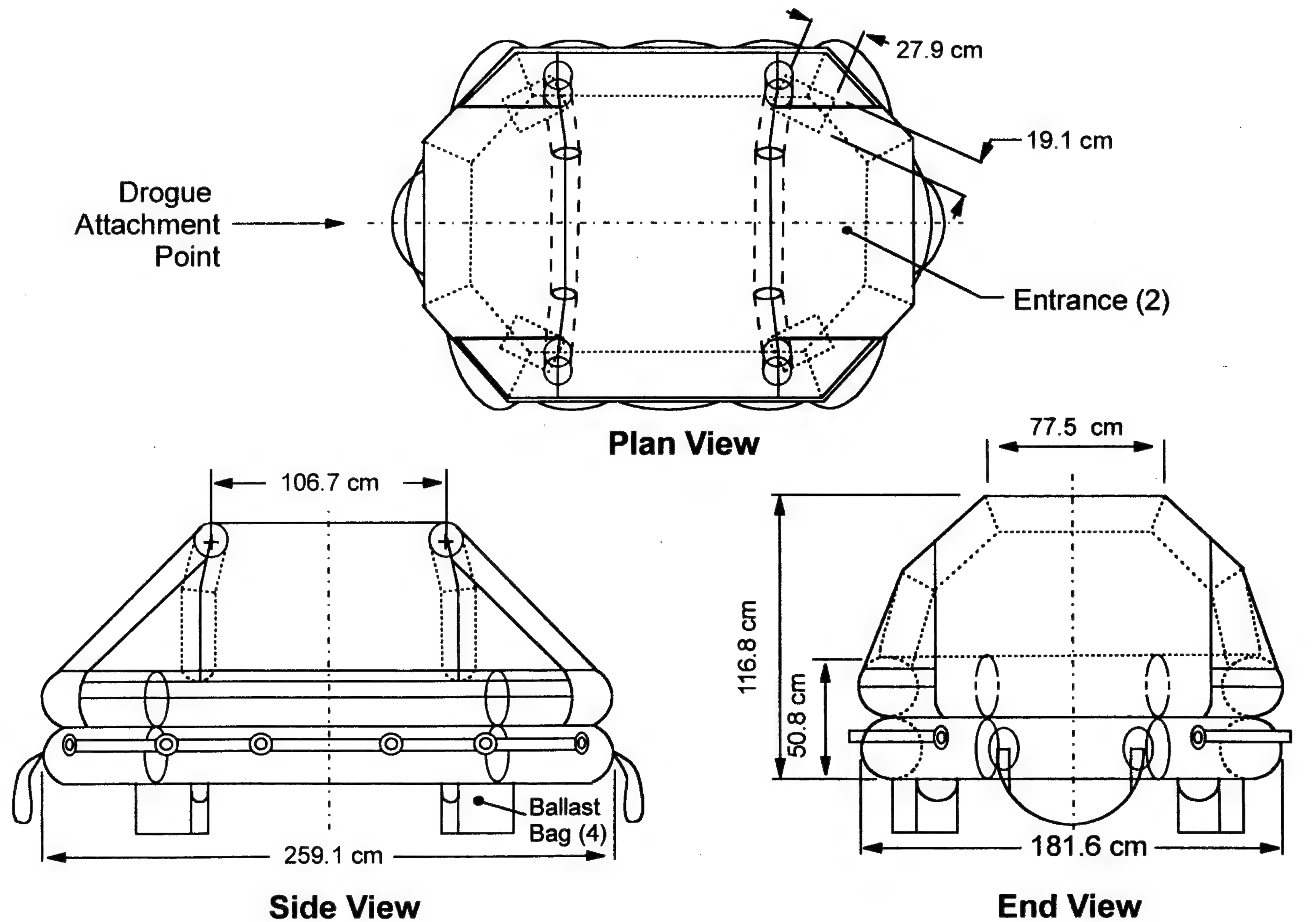


Figure 2-5. The Switlik 6-Person 4-Sided Life Raft "H" with 4 Small Ballast Bags.

### 2.2.4 Dunlop-Beaufort Five-Sided, 4-Person Life Raft (1992 and 1993 experiments)

A Beaufort Five-Sided, 4-Person life raft, shown in Figure 2-6, was used during the 1992 and 1993 leeway field experiments (see Fitzgerald et al. (1994)). Near the end of Leeway Run #22, the Beaufort life raft capsized. During Leeway Run # 22, this life raft had a loading equivalent to 4 persons, and the drogue was deployed. For the analysis conducted by Fitzgerald et al. (1993) and (1994) the data records were truncated after 49 hours and 20 minutes. At this point, the wind monitoring system failed, and the analysis by Fitzgerald et al. (1993) and (1994) was on the standard configuration Beaufort five-sided, 4-person life raft. For this report, the portion of the record when the Beaufort was capsized was analyzed. During Leeway Run # 22, the Beaufort life raft had an S4® EMCM attached, a wind monitoring system, and a Argos beacon. Deployed along side the Beaufort life raft, was a Tulmar 4-person life raft, designated Leeway Run # 23. The Tulmar life raft also had an S4® EMCM attached, a wind monitoring system, and a Argos beacon. The track lines of these two life rafts followed each other (see Fitzgerald et al. (1993), Appendix F). This facilitated using the winds from the Tulmar life raft (Leeway Run # 23) to analyze the leeway of the capsized the Beaufort life raft, (Leeway Run # 22).

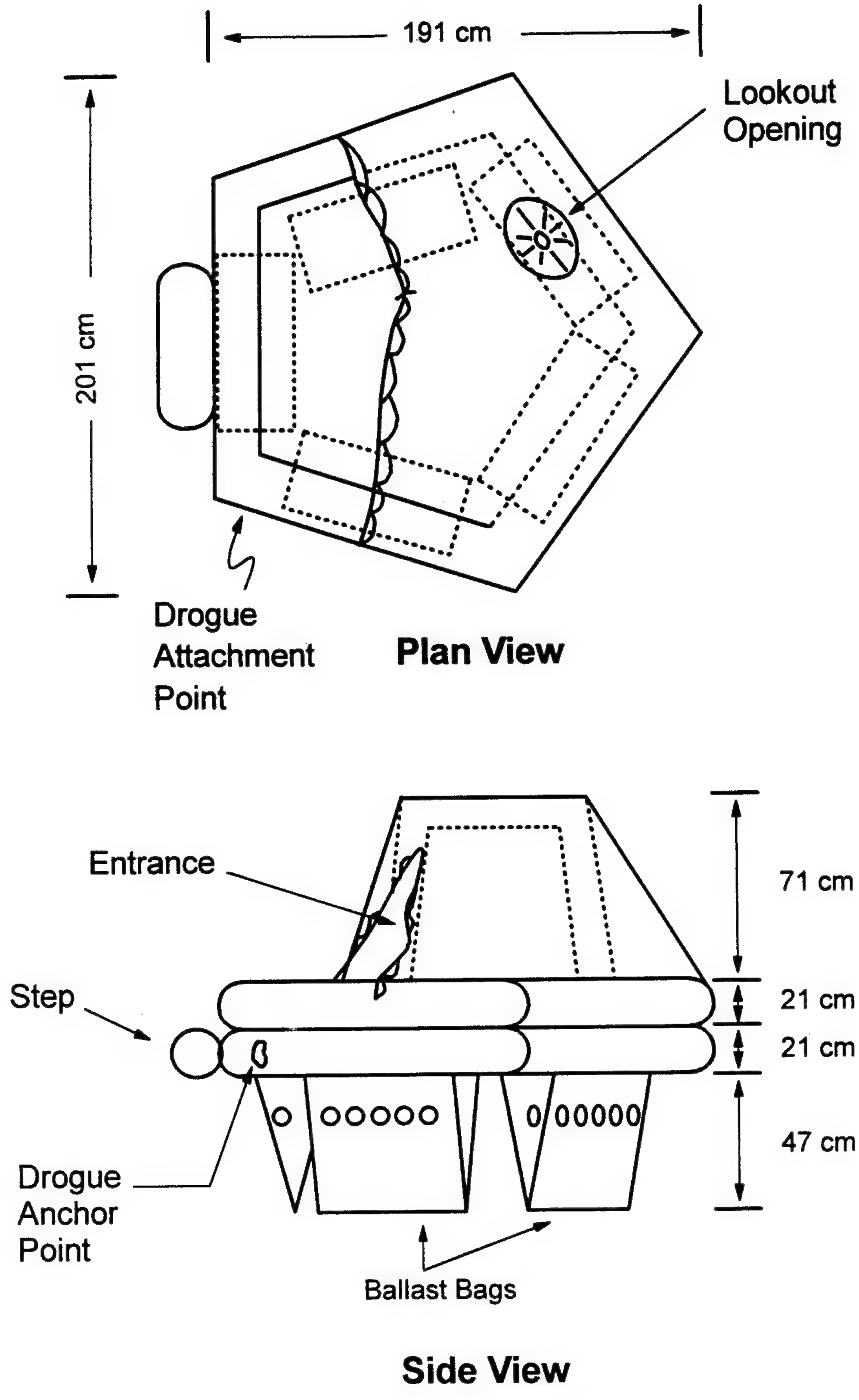


Figure 2-6. The Dunlop-Beaufort Five-Sided, 4-Person Life Raft.

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# CHAPTER 3

# DATA PROCESSING

## 3.1 DEFINITIONS OF PARAMETERS

**Relative Wind Direction** is the direction from which the wind blows, measured in degrees about a chosen axis and reference point of the test craft, as shown in Figure 3-1. Since the onboard wind data was not recovered, there were not any relative wind direction data from this experiment , however relative wind direction from previous experiments are used in the analysis of the open boat's leeway.

**Leeway Angle** is defined as leeway drift direction minus the direction towards which the wind is blowing with a deflection to the right of downwind being positive and to the left being negative, as shown in Figures 3-1 and 3-2. This is the same convention as relative wind direction. A leeway angle of 0 degrees indicates that the craft drifts directly downwind.

**Leeway speed** is the magnitude of the leeway velocity, as shown in Figure 3-2. Leeway speed is always positive. Leeway speed and leeway angle are the polar coordinates for the leeway velocity vector.

**Downwind and Crosswind components of Leeway** are the components of the leeway velocity vector expressed in rectangular coordinates relative to the wind velocity vector (i.e. $\mathbf{W}_{10m}$), as shown in Figure 3-2. The two components of leeway can be positive or negative. However, as a practical matter, the downwind component of leeway is almost always positive. The crosswind component is the divergence of the SAR craft from the downwind direction. Positive crosswind components are divergence to the right of wind and negative crosswind components are divergence to the left of the wind. A clear advantage of using crosswind components of leeway rather than leeway angle to express the divergence of SAR craft from the downwind direction comes at low wind speeds. Since crosswind components of leeway are multiplied by wind speed, the scatter in the crosswind component is reduced compared to the scatter of leeway angles at low wind speeds. The net result is that statistical regressions of the components of leeway can be directly implemented in numerical search planning tools.

**Leeway rate** is defined as the leeway speed ($|\mathbf{L}|$) divided by the wind speed adjusted to the 10 meter reference level ($\mathbf{W}_{10m}$). Taking into account that the units of $|\mathbf{L}|$ are cm/s and the units of $\mathbf{W}_{10m}$ are m/s, the result has units of a percentage of the wind speed.

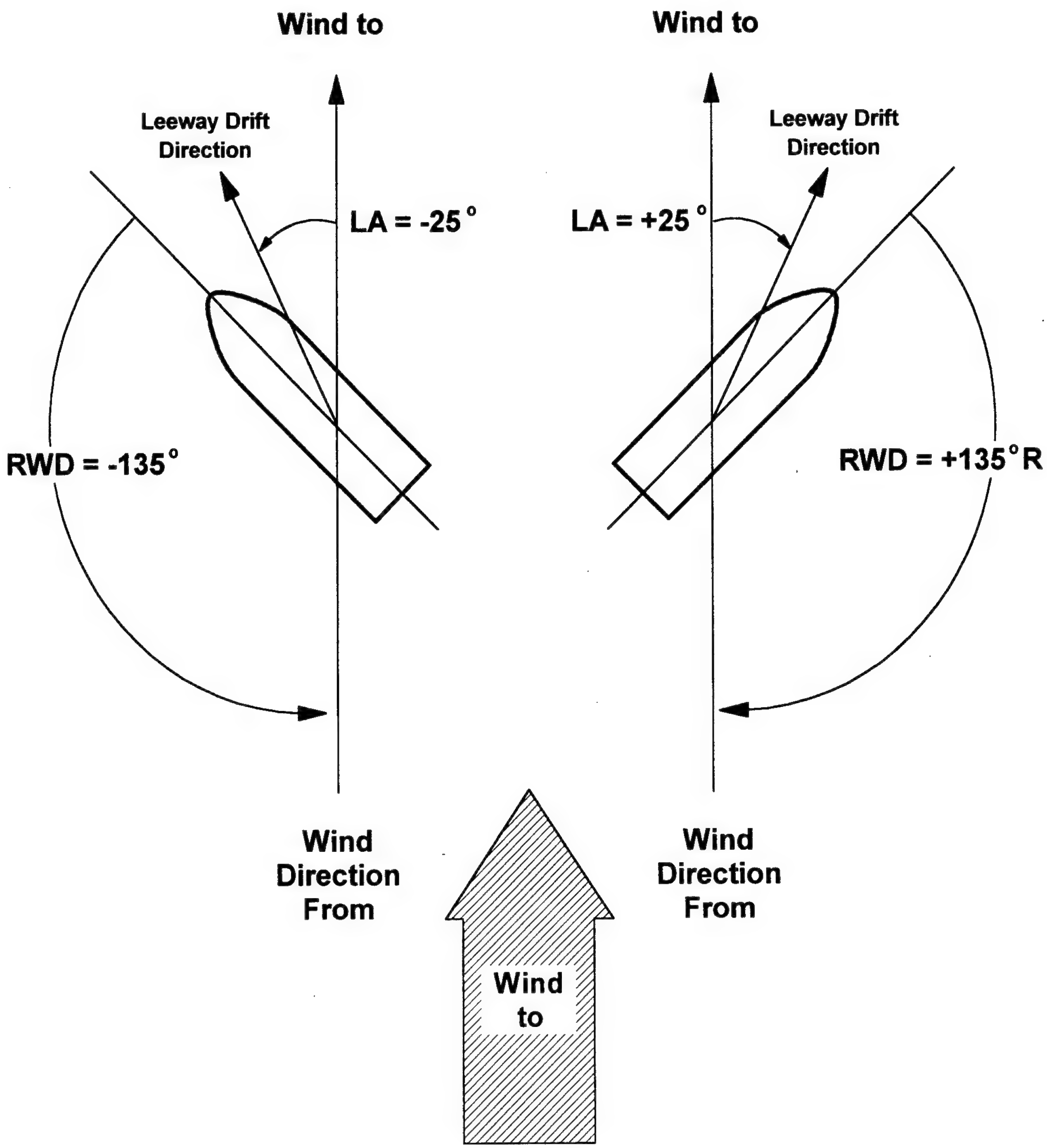
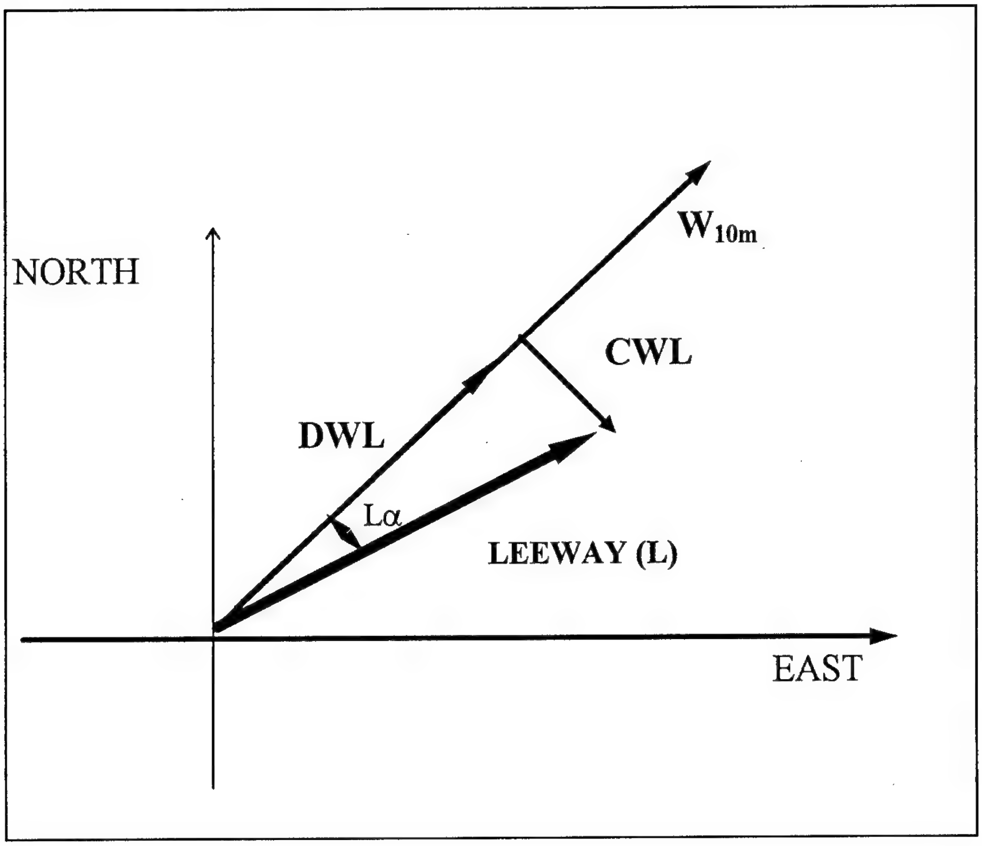



Figure 3-1. Relationship between Relative Wind Direction (RWD) and Leeway Angle (L$\alpha$).




$\mathbf{W}_{10m}$ = Wind velocity vector adjusted to 10m height,
**L** = Leeway vector,
Lα = Leeway angle,

$$\frac{|\mathbf{L}|}{|\mathbf{W}_{10m}|} = \text{Leeway rate,}$$

$$\mathbf{DWL} = |\mathbf{L}|\sin(90^\circ - L\alpha) = \text{Downwind Leeway component,}$$

$$\mathbf{CWL} = |\mathbf{L}|\cos(90^\circ - L\alpha) = \text{Crosswind Leeway component.}$$

Figure 3-2. Relationship between the Leeway Speed and Angle and the Downwind and Crosswind Components of Leeway

## 3.2 ANALYSIS METHODOLOGY

### 3.2.1. Introduction

Analysis methods for leeway data sets are hierarchically dependent upon the quantity and quality of the leeway and wind data available for analysis, as shown in Table 3.1. (1) At the lowest level, when the data are limited to just a few pairs of leeway speed and wind speed data all at essentially same wind speed, then the analysis is limited to just determining a mean leeway rate. (2) When more data pairs are collected, but the range of wind speed is limited, constrained linear regression will provide some preliminary analysis. (3) When the data set is slightly expanded to include leeway speed collected over a larger range of wind speeds, then both unconstrained and constrained regressions of leeway speed on wind speed can be performed. Time series of leeway rate are also possible. (4) When the data set includes accurate measurements of leeway and wind directions collected over a range of wind speeds, then regressions can be performed on the downwind (**DWL**) and crosswind (**CWL**) components of leeway versus wind speed. Since **CWL** can be either positive or negative, an assumption will be made (specifically, that **CWL** is symmetrical about the downwind direction) when fitting regression of **CWL** versus wind speed. Analysis of leeway angle is also possible. (5) When the data set includes multiple drift runs, then the symmetry of **CWL** can be tested with piece-wise regressions of the **CWL** versus wind speed to fully characterize the behavior of that leeway craft. This method of analysis does not require the assumption that the leeway drift of the test craft was symmetrical about the downwind direction.

Table 3.1
Hierarchy of Methods for Leeway Data Analysis

| | Available Leeway and Wind Data | | | | |
|---|---|---|---|---|---|
| Analysis that can be performed | Limited # of Data, at limited Wind Speed | Limited Range of Wind Speeds | Range of Wind Speeds | Wind Direction and Range of Wind Speeds | Multi-Drift Runs over a Range of Wind Speed with Wind Direction |
| Leeway Rate | YES (mean) | YES (mean) | YES (time series) | YES (time series) | YES (time series) |
| Leeway Speed vs. $\mathbf{W_{10m}}$ (Constrained) | NO | YES (preliminary) | YES | YES | YES |
| Leeway Speed vs. $\mathbf{W_{10m}}$ (Unconstrained) | NO | NO | YES | YES | YES |
| Leeway Angle | NO | NO | NO | YES | YES |
| **DWL** vs. $\mathbf{W_{10m}}$ | NO | NO | NO | YES | YES |
| **CWL** vs. $\mathbf{W_{10m}}$ | NO | NO | NO | YES (assume symmetry about the downwind direction) | YES (determine symmetry / non-symmetry) |

The data available for analysis from the 1995 leeway experiment (see sections 3.3 - 3.5) combined with data from the 1992 and 1993 experiments provided data sets that fell into all five categories listed in Table 3.1. Therefore, in this report, analysis of leeway rate is always provided, and when possible the following analyses were conducted depending upon the available leeway data: regression of leeway speed on $\mathbf{W_{10m}}$; analysis of leeway angle, and finally regression of **DWL** and **CWL** on $\mathbf{W_{10m}}$ with out assuming symmetry about the downwind direction of **CWL**.

### 3.2.2 Regression Methods

The definitions and analysis methods follow Allen (1996a). Two linear regression models of leeway speed and both components (downwind and crosswind) of leeway on wind speed were used in this analysis. One regression model was unconstrained and the second was constrained through the origin:

$$\text{Leeway} = a + b * \mathbf{W_{10m}} \qquad (3\text{-}1)$$

(Linear regression, unconstrained)

$$\text{Leeway} = b * \mathbf{W_{10m}} \qquad (3\text{-}2)$$

(Constrained through zero regression)

where: Leeway represents either leeway speed, downwind component of leeway, or the crosswind component of leeway; $\mathbf{W_{10m}}$ is the wind speed adjusted to the 10 meter reference height; and "a" and "b" are regression coefficients. Tables in Chapter 4 contain the regressions of leeway speed and the crosswind and downwind components of leeway on $\mathbf{W_{10m}}$. Each table contains the number of samples (#), the y-intercept (a) and the slope of the regression line (b), the coefficient of determination or variance explained ($r^2$), the standard error of the estimate ($S_{y/x}$), and the range of wind speeds. The y-intercept (a) is in *cm/s*, the slope (b) is in [(*cm/s*)/(*m/s*)] which is *percent*, and variance explained ($r^2$) x 100 = *percent* variance explained.

Prediction limits were used to estimate (with 95% confidence) the upper and lower limits for the next individual outcome (the leeway speed or component) at an estimated wind speed. For a complete description of the statistical techniques used, see Allen (1996a). A second-order polynomial equation was then fitted to each limit over the wind speed range.

$$95\% \text{ Prediction limit} \cong c_1*(\mathbf{W_{10m}})^2 + c_2*(\mathbf{W_{10m}}) + c_3 \qquad (3\text{ - }3)$$

where:

$c_1$ has units of $cm*s*m^{-2}$,
$c_2$ has units of $cm*m^{-1}$, and
$c_3$ has units of $cm*s^{-1}$

The coefficients of the second order polynomials that describe the 95% prediction limits for the regressions are presented for three leeway target types in tables in Chapter 4.

Since all three leeway craft either swamped or capsized, the data records were dividend into two sections for analysis purposes. The analysis was focused on delimiting the difference in leeway behavior between the two phases of the leeway craft.

### 3.2.3 Piece-wise Regression Rules

The crosswind component of leeway versus wind speed is a bi-modal data set, which necessitates a piece-wise scheme for regression analysis purposes. There are a number of legitimate methods for separating the data set into subclasses before applying the regression and after recombining the regressions. The following rules provided the guidance used for piece-wise regressions in this report.

1) All legitimate data pairs shall be used. (All data that was valid was used).
2) Use the data pairs only once. (All good data pairs had a weighting of one.)
3) Make breaks along natural boundaries (Divisions were not random.)
4) Recombine regressions to provide a model that includes most of the original data pairs and excludes regions without data pairs. (Prediction limits encompassed the data and avoided large regions where no observations occurred.)
5) The combined regressions are to be mathematically implemented. (Discontinuities and ambiguities were avoided in the model, to provide smooth transitions with minimum decision rules.)

### 3.2.4 Reference Levels and the Definition of Leeway

The definition of leeway used for this work was presented in section 1.2.1. The analysis of the SAR object leeway is presented relative to the water at 0.75 meter depth. The leeway is expressed in terms of wind velocity corrected for each platform's motion, adjusted to a reference height of 10 meters.

The units used in this report are meters (m) for height and depth, meters per second (m/s) for wind speed, centimeters per second (cm/s) for leeway speed and the leeway components, degrees for angular measurements, degrees Celsius for air and water temperatures and time is the Universal Time Coordinate (UTC) hour of the day. Local time was UTC+3.5 hours.

## 3.3 SUMMARY OF DATA RECOVERY

A full and complete leeway data set was not recovered during the experiment. The sea conditions exceeded the capabilities of the open boats and life rafts. Table 3-2 lists the leeway data that were recovered during the November - December 1995 field experiment.

Table 3-2
Summary of Data Recovered
Grand Banks of Newfoundland, November - December 1995

| Leeway Craft | Leeway Run # | No. of Argos Positions | GPS Positions | Wind Data | Leeway Data |
|---|---|---|---|---|---|
| Boat #1 | 60 | 9 | 3.0 days | MiniMet | 6.0 days |
| Boat #2 | 61 | 2 | None | None | None |
| Boat #3 | 62 | 46 | None | None | None |
| Raft "J" | 63 | 49 | None | MiniMet | 5.7 days |
| Raft "H" | 64 | 70 | None | MiniMet | 6.9 days |

## 3.4 SUMMARY OF DATA REDUCTION

The raw leeway data sets were edited to include only those sampling intervals when the craft was free-drifting and clear of interference. The raw wind and leeway samples were ten minute vector averages. The basic procedures followed Fitzgerald et al. (1993), Fitzgerald et al.. (1994) and Allen (1996a). Time is expressed in Universal Coordinate Time (UTC) at the center of each 10-minute sample.

The wind data from the MiniMet® buoy were used for this experiment. Raw Wind data were rotated (-22.545 degrees) from magnetic to true coordinates, and then rotated 180 degrees to convert from the meteorological to the oceanographic convention. The MiniMet's® anemometer had a clean air flow, with minimum buoy motion. The total wind direction error based on the calibration of the MiniMet's® anemometer and compass was estimated to have been plus or minus 2 degrees. Wind speed was adjusted from the anemometer level (3.0 m) to the 10-meter reference height using the algorithm described by Smith (1981). The wind vectors adjusted to the 10-meter reference height are referred to in this report as $\mathbf{W}_{10m}$.

The distances of the leeway craft from the MiniMet® buoy are summarized in Table 3-3.

The number of positions include positioning of the craft by the vessel upon deployment and recovery, and during the drift by radar fixes, on board GPS, and Argos positioning. A GPS record was returned only from the first half of the Boat #1 drift. The Boat #1 Argos beacon failed 13.5 hours after deployment. The Boat #2 Argos transmitter was damaged on deployment and did not work after deployment, resulting in a single fix at deployment and one additional radar fix. Boat #3 had Argos

positions up until day 334 at 14:51, 115 hours after deployment. Both Rafts "J" and "H" had Argos positions from time of deployment through to recovery.

Table 3-3
Distance of the Leeway Craft from the MiniMet® Buoy
Grand Banks of Newfoundland, November - December 1995

| Leeway Craft | Leeway Run # | Number of Positions | Distance from MiniMet Buoy (km) | | |
|---|---|---|---|---|---|
| | | | Mean | Min | Max |
| Boat #1 | 60 | 882 | 30.6 | 8.2 | 48.1 |
| Boat #2 | 61 | 2 | N/A | 33.8 | 39.5 |
| Boat #3 | 62 | 46 | 26.9 | 4.5 | 40.7 |
| Raft "J" | 63 | 49 | 33.2 | 13.4 | 53.3 |
| Raft "H" | 64 | 70 | 33.0 | 3.5 | 51.8 |

The 10-minute averages from the S4® EMCMs were used for leeway and were edited by removing the portions of records before and after the leeway runs. The records were rotated -22.545 degrees to convert from magnetic north to true north. The velocities were rotated 180 degrees to convert the relative motion of the water past the current meter to true motion of craft through the water. The leeway records were synchronized with the wind records and combined together into arrays.

The GPS position records used to track the drift of the craft were also edited to remove the portions before and after the actual drift.

Leeway data were matched in time with the corresponding wind data. Leeway angle, and the downwind and crosswind components of leeway were calculated by using the 10-minute vector averaged wind direction from the MiniMet® buoy. Leeway rate was calculated using $\mathbf{W}_{10m}$ from the MiniMet® buoy.

## 3.5 SUMMARY OF THE DATA SET

Table 3-4 provides a summary by drift run of the data sets collected during the November - December 1995 field work. Wave height is significant wave height measured by the MiniMet® buoy.

Table 3-4
Summary of Leeway Drift Runs
Grand Banks Newfoundland, November - December 1995

| CRAFT | LEEWAY RUN # | DATA (hh:mm) | $W_{10m}$ (m/s) | Wave Height (m) |
|---|---|---|---|---|
| 5.5m open boat | 61 | 123:10 | 2.2 - 22.2 | 1.5 - 9.3 |
| life raft "J" | 63 | 118:20 | 2.2 - 22.2 | 1.5 - 9.3 |
| life raft "H" | 64 | 166:30 | 2.1 - 22.0 | 2.2 - 9.1 |

Additional leeway data runs are available from the 1992 and 1993 field trials. Table 3-5 lists those runs for the 5.5m open boat.

Table 3-5
Summary of Previous Leeway Drift Runs
for 5.5m Open Boat
Grand Banks Newfoundland, 1992 and 1993

| CRAFT | LEEWAY RUNS # | DATA (hh:mm) | $W_{10m}$ (m/s) | Wave Height (m) |
|---|---|---|---|---|
| 5.5m open boat | 21,27,29, 31,33,46,56 | 171:50 | 0.2 - 14.4 | 1.3 - 6.5 |

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# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 GENERAL

Five leeway runs were conducted off St. John's Newfoundland, between 2 November (Yearday 329) and 7 December (Yearday 341) 1995. The Canadian Coast Guard Ship SIR HUMPHREY GILBERT served as support vessel for this experiment. In addition to the leeway studies, radar detection studies (see Fitzgerald (1996)) and performance studies of SLDMBs (see Allen (1996b)) were conducted. Leeway runs 61-63 were deployed on 25 November, however, the MiniMet® buoy was deployed 26 November (Yearday 330). Therefore the analysis for these runs start at the time of the anchor release of the MiniMet® buoy (14:55 UTC, Yearday 330, 1995). Each leeway run was started within 50 km of the MiniMet® buoy and the leeway targets were allowed to freely drift. Distances of the SAR craft from the MiniMet® buoy ranged from 4 to 53 kilometers, as shown previously in Table 3-2.

Wind speed data from the MiniMet® buoy appears to be uncontaminated throughout the mooring record. However, wind direction only agrees with AES surface analysis charts from the start until yearday 331 12:15 UTC. After this time, the leeway analysis for this data set is limited to leeway rate and leeway speed versus wind speed. Since leeway angle and the downwind and crosswind components of leeway are directly dependent on wind direction, the values after 331 12:15 UTC were not used in the analysis.

Winds during the experimental period were generally strong (2.2 - 22.2 m/s, with a mean of 9.6 m/s) with large waves and swells (1.5 - 9.3 m). During the experimental period, the wind speed exceeded 15 m/s four times and 20 m/s twice. Significant wave height and wind speed adjusted to the 10 meter level from the MiniMet® buoy are shown in Figure 4-1.

Air temperature ranged from -3.1 to 12.2 degrees Celsius and sea surface temperature decreased from 7.0 to 4.4 degrees Celsius over the 11 day mooring period as shown in Figure 4-2. Barometric pressure varied from 980 to 1031 mbars as four low pressure systems passed through the area, also shown in Figure 4.2.

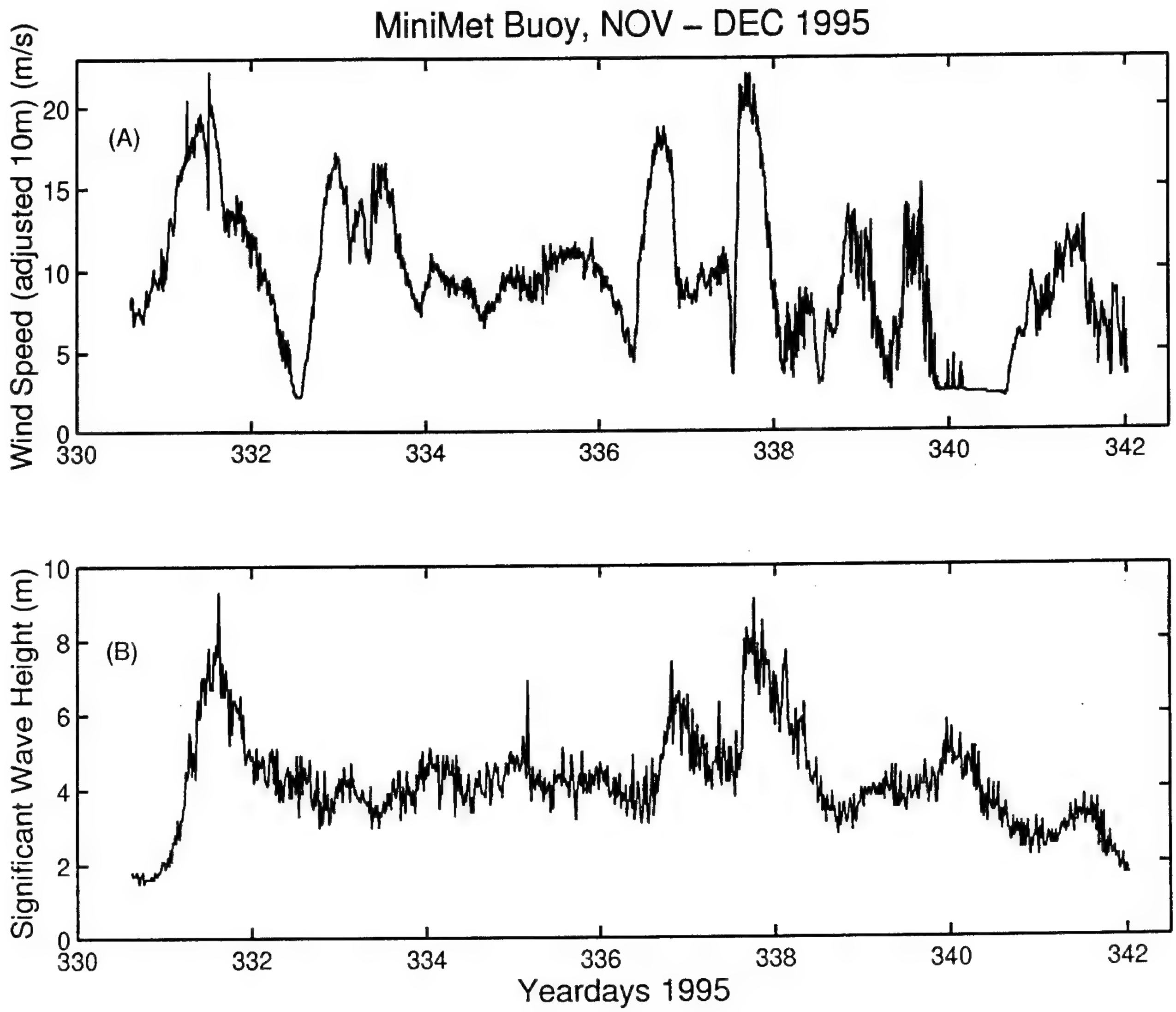


Figure 4-1. Time Series of 10-meter Wind Speed (A) and Significant Wave Height(B) from the MiniMet® buoy.

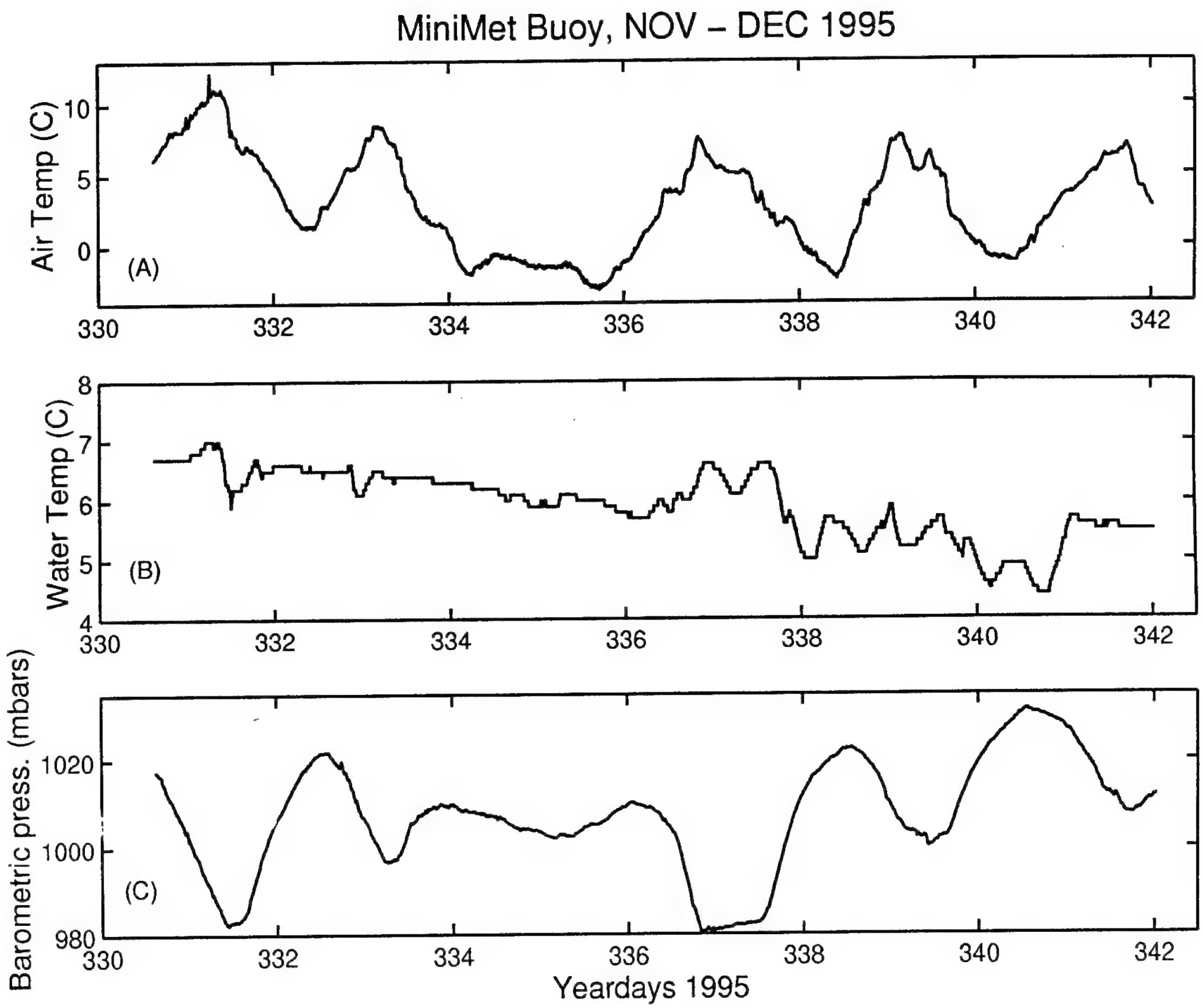


Figure 4-2. Time Series of Air Temperature (A)Water Temperature (B) and Barometric Pressure (C) from the MiniMet® buoy.

## 4.2 5.5-Meter WOODEN-PLANKED OPEN BOAT

Leeway run # 60 was started when 5.5 m open boat #1 was deployed at 17:58 UTC on 25 November 1995. Wind data were available from 14:55 UTC, Yearday 330, 1995 until the end of the record at 335 17:55. Data for Boat #1 consist of 739 ten-minute averages collected during the last 5.13 days of the 6.0 day drift period. The 10 meter wind speed ranged from 2.2 to 22.2 m/s, with significant wave heights of 1.5 to 9.3 meters.

Boat #1 had a outboard motor in the down position. When Boat #1 was recovered in a swamped condition on 1 December, it was missing the motor, the Weatherpak® wind monitoring system, the GPS receiver/antenna, the radar reflector and its mast, and the hatch was partially open. During the recovery approach, the SIR HUMPHREY GILBERT dropped its bow on Boat #1, resulting in the capsizing of Boat #1, complete removal of the hatch, and crushing of the Weatherpak® mast. Boat #1 was then recovered, along with the GPS data logger, Weatherpak® battery canister, and the tethered S4®EMCM. The gel-cell battery pack for the GPS data logger was missing.

It is evident that the leeway craft changed phase from a standard configuration open boat to a swamped open boat during this leeway run. Since the craft was not equipped with pitch and roll sensors, we can only surmise as to when this event actually happened. Before the data record was divided into two parts (standard configuration and swamped), we had to estimate when the swamping event occurred.

### 4.2.1 The Swamping of 5.5m open boat #1

The time series of leeway rate, figure 4-3, clearly shows that the leeway rate fell below 3.0 percent at 22:45 UTC on yearday 332, (time 332.94) and remained below 3.0 percent until Boat #1 was recovered. Four hours earlier, the last GPS position was recorded at 18:40 UTC. The termination of GPS positioning was probably due to either the battery becoming loose inside the boat and disconnecting from the receiver or loss of the GPS antenna/receiver from the mast. Both scenarios suggest that the boat was wildly pitching or rolling during this time. If the battery case was loose and rolling around inside the boat, it might have contributed to the partial shifting of the hatch. With the hatch not completely secured, the boat could then take on water. The leeway rate record indicates this happened at about 22:45 UTC. The data for Boat #1 were therefore divided into two time segments, before 22:45 UTC, yearday 332 and after that time. During the first time segment, the boat was in its "standard configuration" and during the second segment it was "swamped." Table 4-1 presents a summary of the environmental conditions which prevailed during the two time segments.

Table 4-1
Summary of Data for the 5.5m Wooden-Planked Open Boat #1

| CRAFT | LEEWAY RUN | DATA (hh:mm) | $W_{10m}$ (m/s) | Wave Height (m) |
|---|---|---|---|---|
| 5.5m wooden-planked open boat #1 | Total | 123:10 | 2.2 - 22.2 | 1.5 - 9.3 |
| | Std. Config. | 55:50 | 2.2 - 22.2 | 1.5 - 9.3 |
| | Swamped | 67:20 | 6.5 - 17.2 | 3.0 - 6.9 |

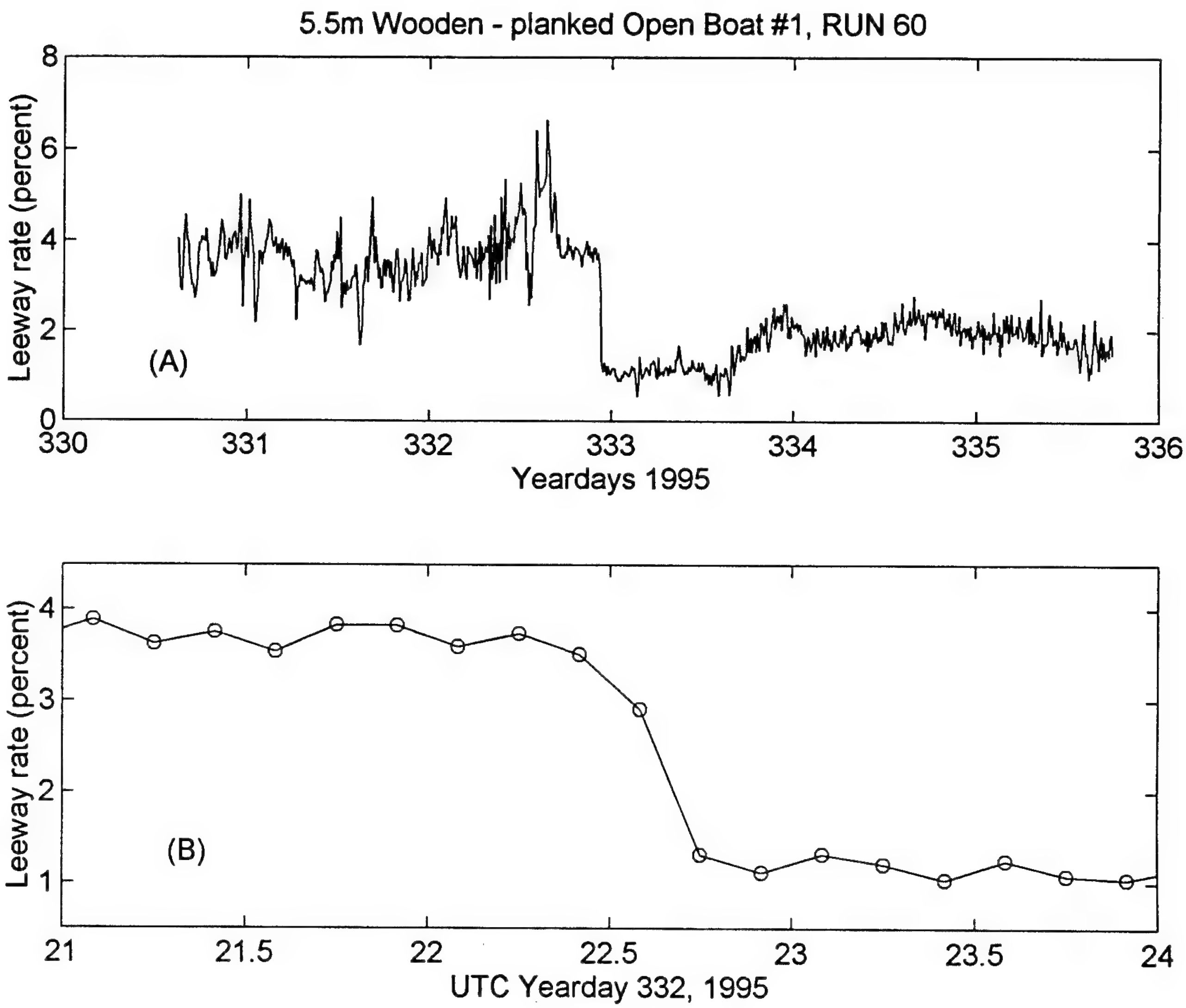


Figure 4-3. Time Series of Leeway Rate for the 5.5m wooden - planked open boat #1, Leeway Run 60. (A) is the complete record, while (B) is the last 3 hours of Yearday 332, 1995.

### 4.2.2 The Leeway of Standard Configuration 5.5m Open Boat #1

Three categories of the standard configuration wooden-planked open boat are discussed below. The first category is the open boat Leeway Run 60 - Standard Configuration. The open boat used for Leeway Run 60 was the same boat used for seven previous leeway runs in 1992 and 1993. Data from these previous runs constitutes the second category and will be referred to as the Previous 7 Runs. The third category is the combination of the first two categories - Combined 8 Runs. This third data category does not include the swamped portion of Leeway Run 60.

An important distinction between the Previous 7 Runs and Leeway Run 60 was the source of the wind data. For the Previous 7 Runs the wind source was a Coastal Climate Weatherpak® wind monitoring system on board the boat. See Allen (1996a) for a description of the on board Coastal Climate Weatherpak® wind monitoring system, and Fitzgerald et al (1993) and (1994) for description of the initial results. The wind source used for Leeway Run 60 is the moored MiniMet® buoy which was 8 to 48 kilometers from Boat #1.

#### 4.2.2.1 Leeway Angle, Rate and Speed

The values of leeway angle were limited to 128 data points collected between 330 14:55 UTC and 331 12:15 UTC. The leeway angle of Standard Configuration Boat #1 Leeway Run 60 shows considerable scatter below wind speeds of 3 m/s. Leeway angle ranged from -39° to +45°, with a mean of -13.7° and a standard deviation of 18.5°. The mean absolute value for leeway angle was 21.6° with a standard deviation 7.9°.

The leeway angle during Previous 7 Runs has scatter at wind speeds below 3 m/s, but becomes increasingly confined near zero for winds from 5 to 10 m/s. Above 10m/s wind speeds, the leeway angle shows a distinct bifurcation. Leeway angle ranged from -43° to +46°, with a mean of -4.0° with a standard deviation of 9.1°. The mean absolute value for leeway angle was 7.2° and a standard deviation of 6.8 °. The leeway angle for the Previous 7 Runs has considerable less scatter at all wind speeds above 6.7 m/s than for Leeway Run 60 - Standard Configuration, (Figure 4-4). Since the Previous 7 Runs wind data were all collected on board the boat there was not any separation of the craft from the source of the wind data, as was the case with Leeway Run 60. Leeway angle for the open boat is summarized in Table 4-2.

The leeway angle from the Combined 8 Runs were divided by wind speed and also presented in its entirety. The first division is based upon the winds greater than or less than 5 m/s. This division provides leeway angle statistics comparable to Fitzgerald et al. (1994), where they separated leeway angles based upon wind greater than or less than 10 knots (5.14444 m/s). Allen and Staubs (1997) used twice the standard deviation of the leeway angle when the winds were greater than 10 knots for CASP User Defined Leeway Inputs - divergence angle. The standard deviation of leeway angle for wind from 5.0 to 20.4 m/s for the open boat was 10.1 degrees. Twice the standard deviation is therefore, 20 degrees, which is the value

recommended Table 5-4 for the divergence angle for the CASP User Defined Leeway input for open-boats.

The second division of the leeway angle of the Combined 8 Runs was based winds greater than or less than 10m/s, where the values particular from the Previous 7 Runs had shown a distinct bifurcation.

Table 4-2
Leeway Angle (degrees)
5.5m Wooden-Planked Open Boat #1 - Standard Configuration

| Leeway Run | # samples | $W_{10m}$ (m/s) | Leeway Angle mean | s.dev. | min | max | Abs. Angle mean | s.dev. |
|---|---|---|---|---|---|---|---|---|
| 60 - Std. Config. | 128 | 6.7 - 20.4 | -13.7 | 18.5 | -39 | 45 | 21.6 | 7.9 |
| Previous 7 | 1035 | 0.2 - 14.4 | -4.0 | 9.1 | -43 | 46 | 7.2 | 6.8 |
| Combined 8 | 260 | 0 - 5 | -7.5 | 13.2 | -43 | 46 | 12.1 | 9.2 |
| | 903 | 5 - 20.4 | -4.3 | 10.1 | -39 | 44 | 7.8 | 7.7 |
| | 735 | 0 - 10 | -5.8 | 11.0 | -43 | 46 | 9.3 | 8.2 |
| | 428 | 10 - 20.4 | -3.7 | 10.8 | -34 | 44 | 7.8 | 8.3 |
| | 1163 | 0 - 20.4 | -5.0 | 11.0 | -43 | 46 | 8.8 | 8.2 |

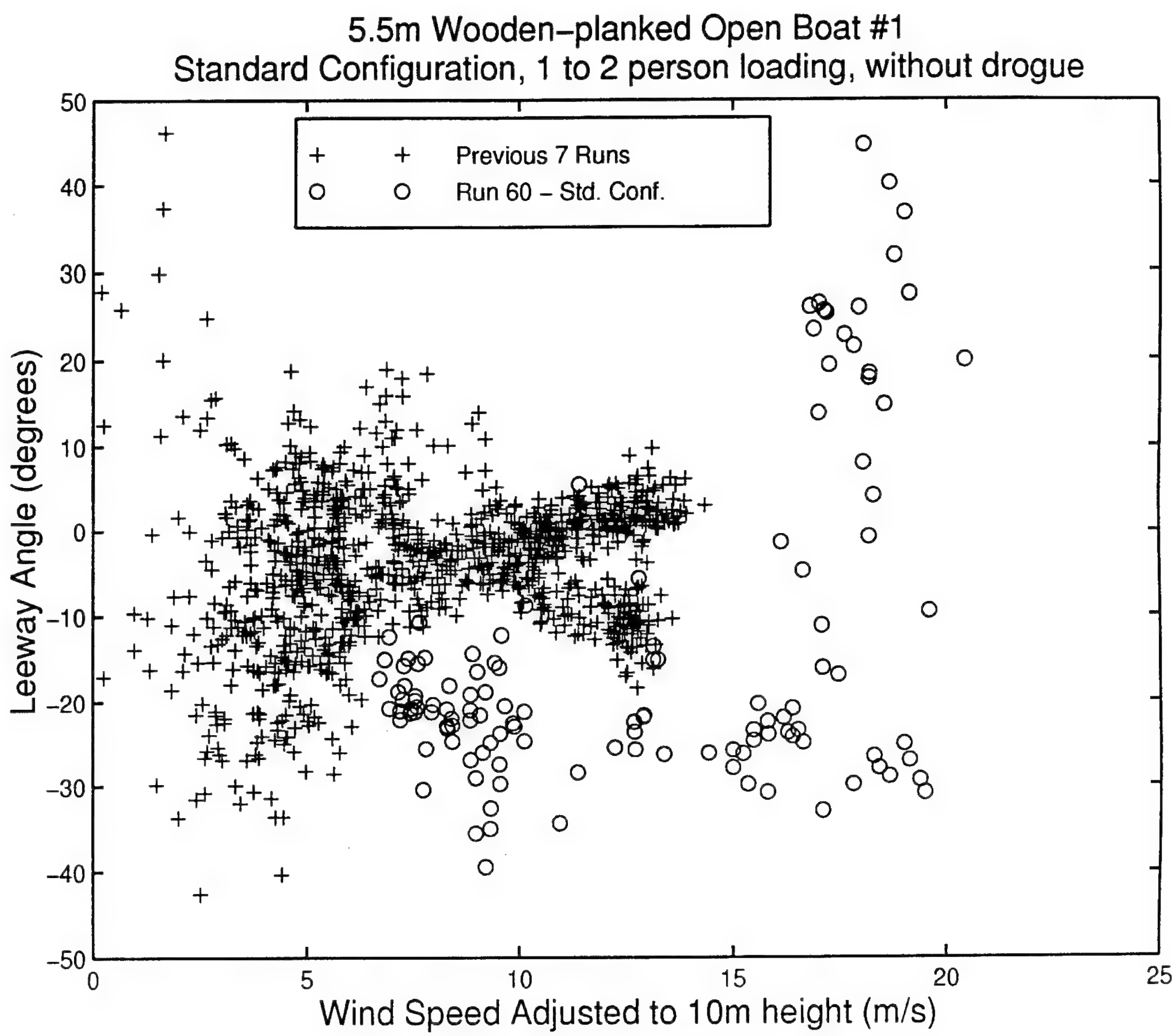


Figure 4-4. Leeway Angle versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat, Previous 7 Runs and Leeway Run 60 - Standard Configuration.

The leeway rate for Run 60, open boat #1 in the Standard Configuration, was based upon 335 data points between the start of the combined records of the Boat and the MiniMet® buoy at 330 14:55 UTC and when the boat swamped at 332 22:45 UTC. The mean leeway rate for the open boat #1 Run 60 - Standard Configuration was 3.69% with a standard deviation of 0.67%, and a range from 1.7% to 6.6%. The leeway rates had a trend that decreased with increasing wind speed in the presence of considerable scatter.

The mean leeway rate for the Standard Configuration open boat #1 Previous 7 Runs was 3.64% with a standard deviation of 1.87%, and a range from 1.5% to 45.2%. Leeway rate for Previous 7 Runs contain less scatter about the mean than the values from Leeway Run 60 - Standard Configuration, Figure 4-5. Missing from Figure 4-5 are five values of leeway rate that are greater than 10% for winds speeds below 1 m/s. As wind speed approaches zero, the leeway rate can grow unrealistically large. Leeway rate for the open boat is summarized in Table 4-3.

Table 4-3

Leeway Rate (Percent of $\mathbf{W}_{10m}$)
5.5m Wooden-Planked Open Boat #1
Standard Configuration

| Leeway Run | # samples | Leeway Rate mean | s.dev. | min | max |
|---|---|---|---|---|---|
| 60 - Std. Config. | 335 | 3.69 | 0.67 | 1.7 | 6.6 |
| Previous 7 | 1035 | 3.64 | 1.87 | 1.5 | 45.2 |
| Combined 8 | 1370 | 3.65 | 1.66 | 1.5 | 45.2 |

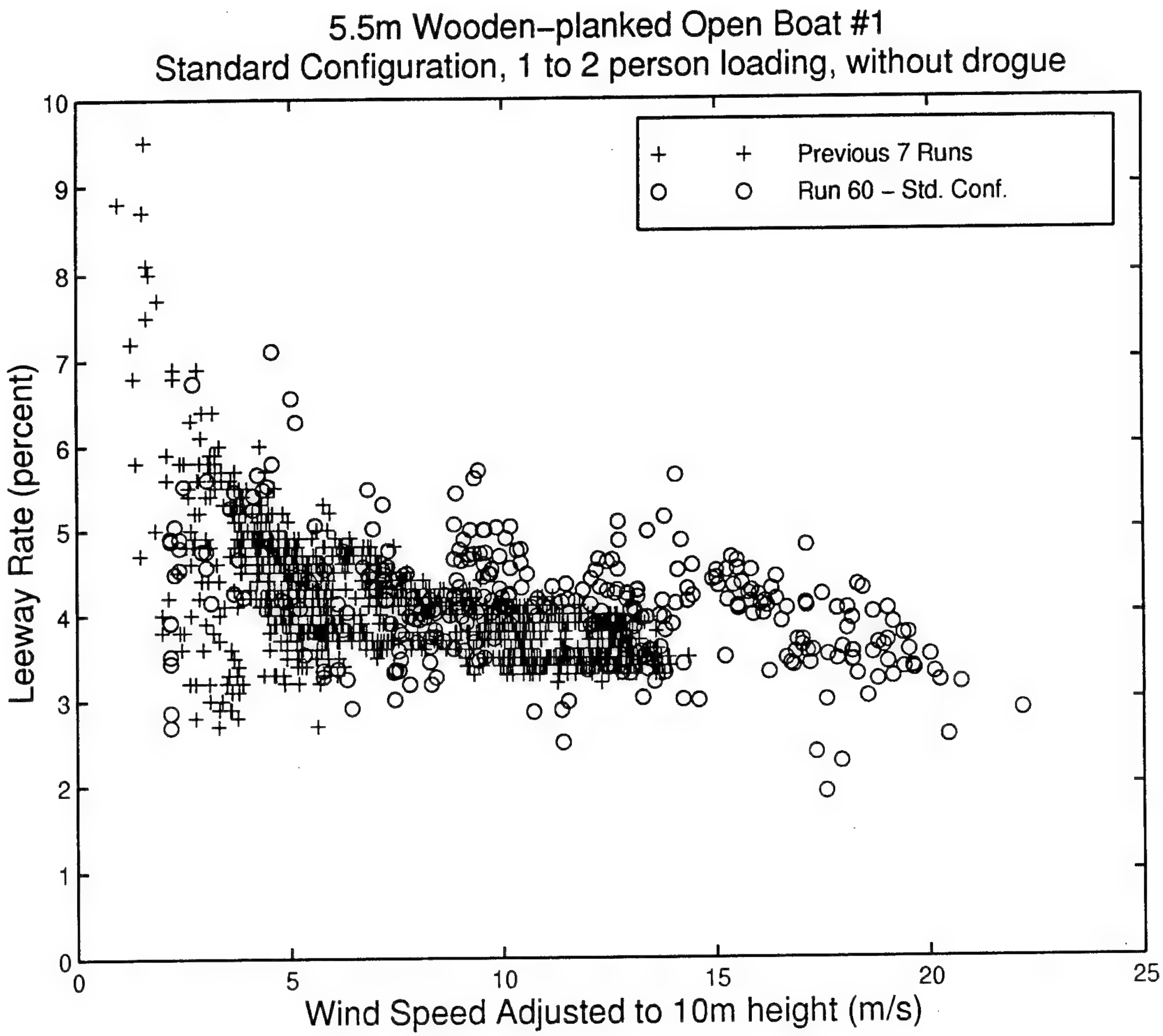


Figure 4-5. Leeway Rate versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat, Previous 7 Runs and Leeway Run 60 - Standard Configuration.

The leeway speed for Run 60, open boat #1 - Standard Configuration was based upon 335 data points between the start of the combined records of the Boat and the MiniMet® buoy at 330 14:55 UTC and when the Boat swamped at 332 22:45 UTC. The leeway speed of the 5.5m open boat is shown in Figures 4-6 through 4-11 for the three categories of data. Unconstrained and constrained linear regression lines along with the 95% prediction limits of leeway speed on wind speed are also shown. Unconstrained linear regression results are summarized in Table 4-4 and the constrained linear regression results are summarized in Table 4-5. The unconstrained linear and constrained linear regressions are virtually the same for the three categories. However, it is the spread of the 95% prediction limits that differs. The polynomial coefficients for the 95% prediction limits are summarized in Tables 4-6 and 4-7. The largest spread was found in Leeway Run 60 - Standard Configuration, and the smallest spread in the Previous 7 Runs. The 95% prediction limits reflect the spread of the data about the mean regression. Since Leeway Run 60 - Standard Configuration had wind data collected remotely from the craft, this increase in leeway noise is reflected in the wider 95% prediction limits. The prediction limits for the Combined 8 Runs lies between the two other categories' 95% prediction limits. The mean and 95% prediction limits for the constrained regressions follow the same pattern as the unconstrained regressions.

Table 4-4

Unconstrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1- Standard Configuration

| Dependent Variable | Leeway Run | # samples | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| Leeway Speed | 60 - Std. Config. | 335 | 7.6 | 2.86 | 0.835 | 6.04 | 2.2 - 22.2 |
| Leeway Speed | Previous 7 | 1035 | 4.1 | 2.89 | 0.916 | 2.96 | 0.2 - 14.4 |
| Leeway Speed | Combined 8 | 1370 | 3.9 | 3.00 | 0.895 | 4.14 | 0.2 - 22.2 |

Table 4-5

Constrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1- Standard Configuration

| Dependent Variable | Leeway Runs | # samples | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| Leeway Speed | 60- Std. Config. | 335 | 0.0 | 3.44 | 0.796 | 6.71 | 2.2 - 22.2 |
| Leeway Speed | Previous 7 | 1035 | 0.0 | 3.33 | 0.891 | 3.37 | 0.2 - 14.4 |
| Leeway Speed | Combined 8 | 1370 | 0.0 | 3.37 | 0.879 | 4.45 | 0.2 - 22.2 |

Table 4-6

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Unconstrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1
Standard Configuration

| Leeway Runs | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1(W_{10m})^2$ | $c_2(W_{10m})$ | $c_3$ | $c_1(W_{10m})^2$ | $c_2(W_{10m})$ | $c_3$ |
| Run 60 - Std. Config. | 0.0008 | 2.88 | 19.57 | -0.0008 | 2.88 | -4.42 |
| Previous 7 | 0.0002 | 2.28 | 9.91 | -0.0002 | 2.89 | -1.71 |
| Combined 8 | 0.0002 | 3.00 | 12.0 | -0.0002 | 3.00 | -4.22 |

Table 4-7

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Constrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1
Standard Configuration

| Leeway Runs | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1(W_{10m})^2$ | $c_2(W_{10m})$ | $c_3$ | $c_1(W_{10m})^2$ | $c_2(W_{10m})$ | $c_3$ |
| Run 60 - Std. Config. | 0.0001 | 3.43 | 13.2 | -0.0001 | 3.43 | -13.2 |
| Previous 7 | 0.0 | 3.33 | 6.62 | 0.0 | 3.33 | -6.62 |
| Combined 8 | 0.0 | 3.37 | 8.73 | 0.0 | 3.37 | -8.73 |

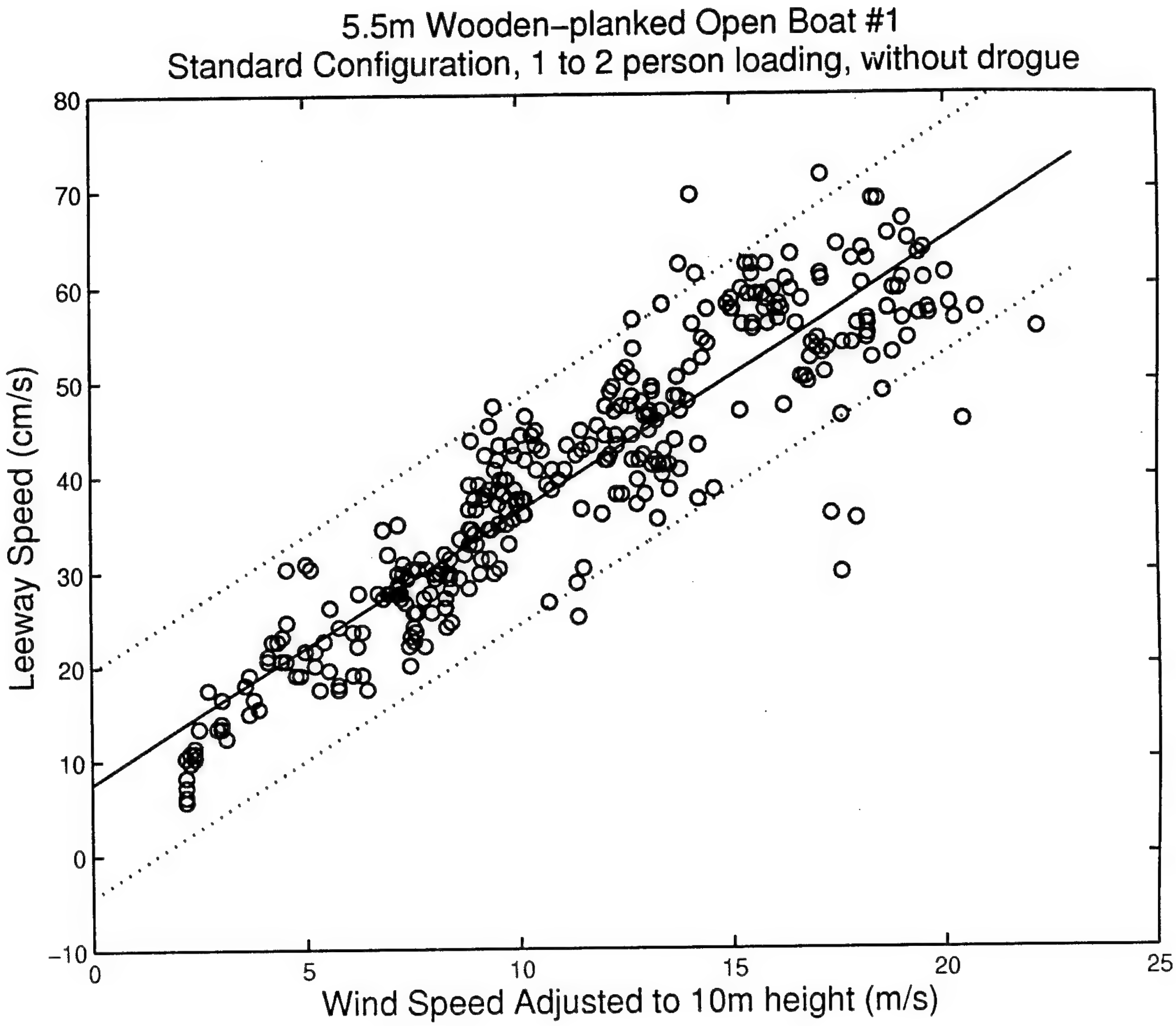


Figure 4-6. The Unconstrained Linear Regression and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat #1, Leeway RUN 60 - Standard Configuration

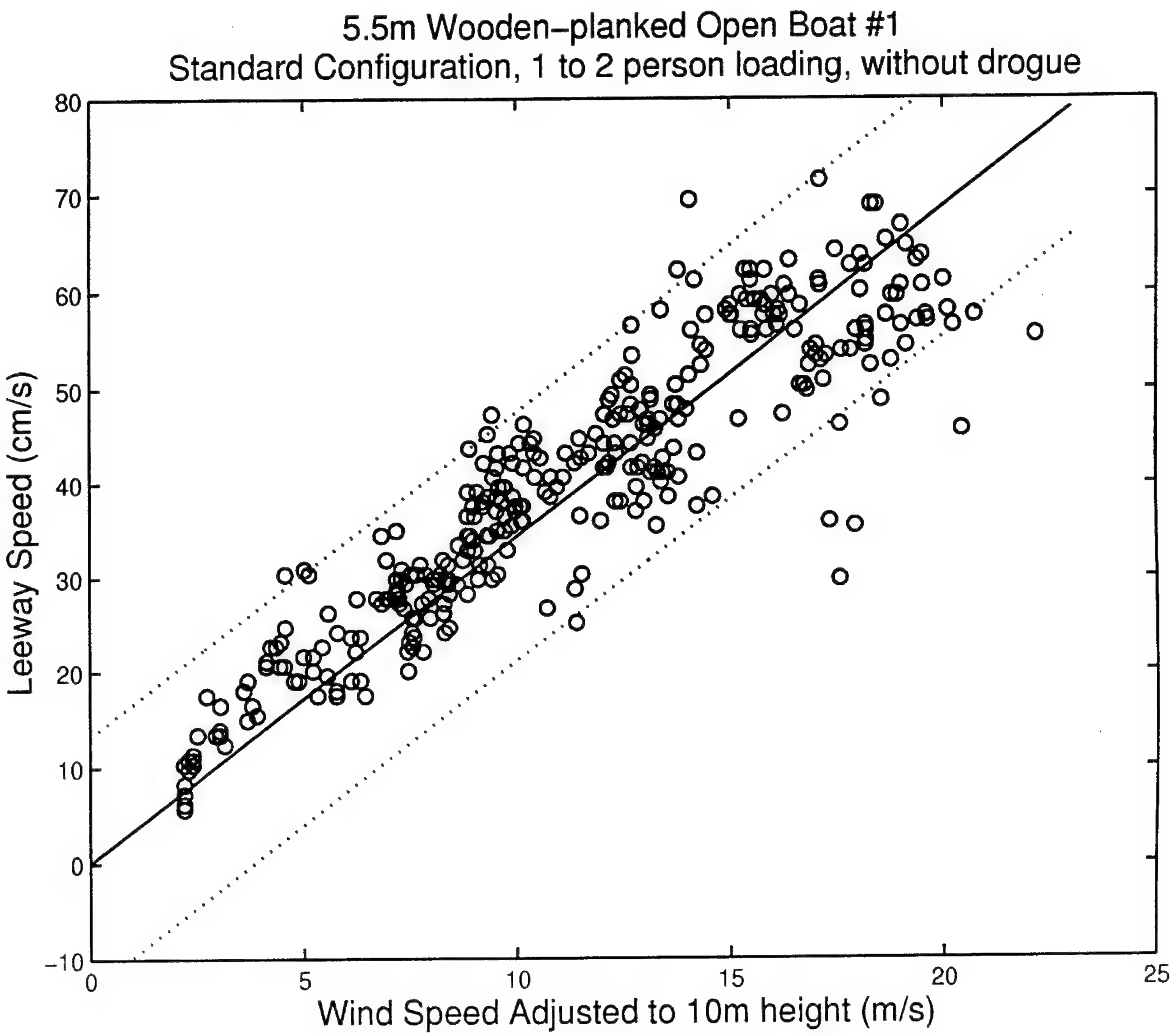


Figure 4-7. The Constrained Linear Regression and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat #1, Leeway RUN 60 - Standard Configuration

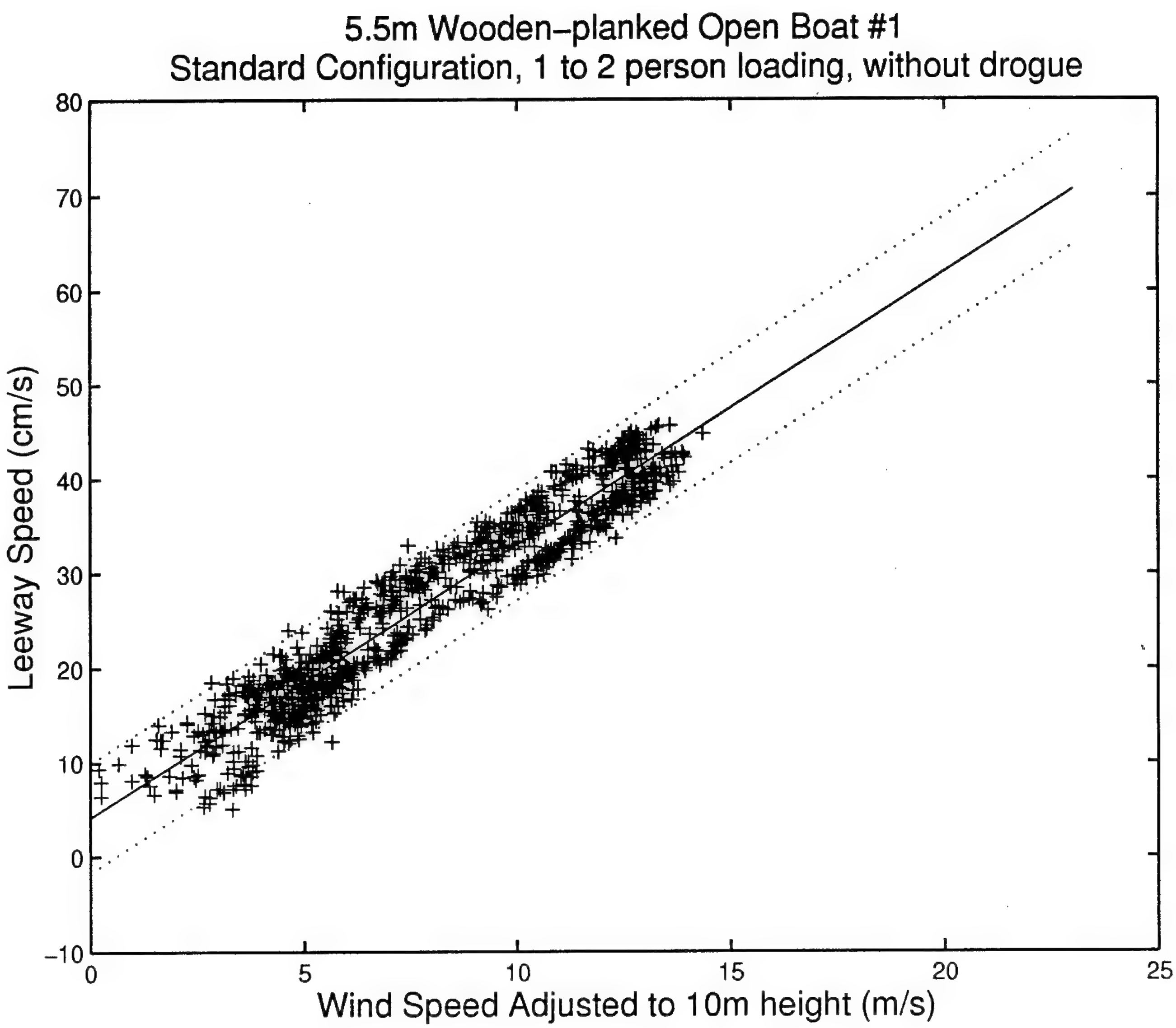


Figure 4-8. The Unconstrained Linear Regression of Leeway Speed and 95% Prediction Limits versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat #1, Previous 7 Runs

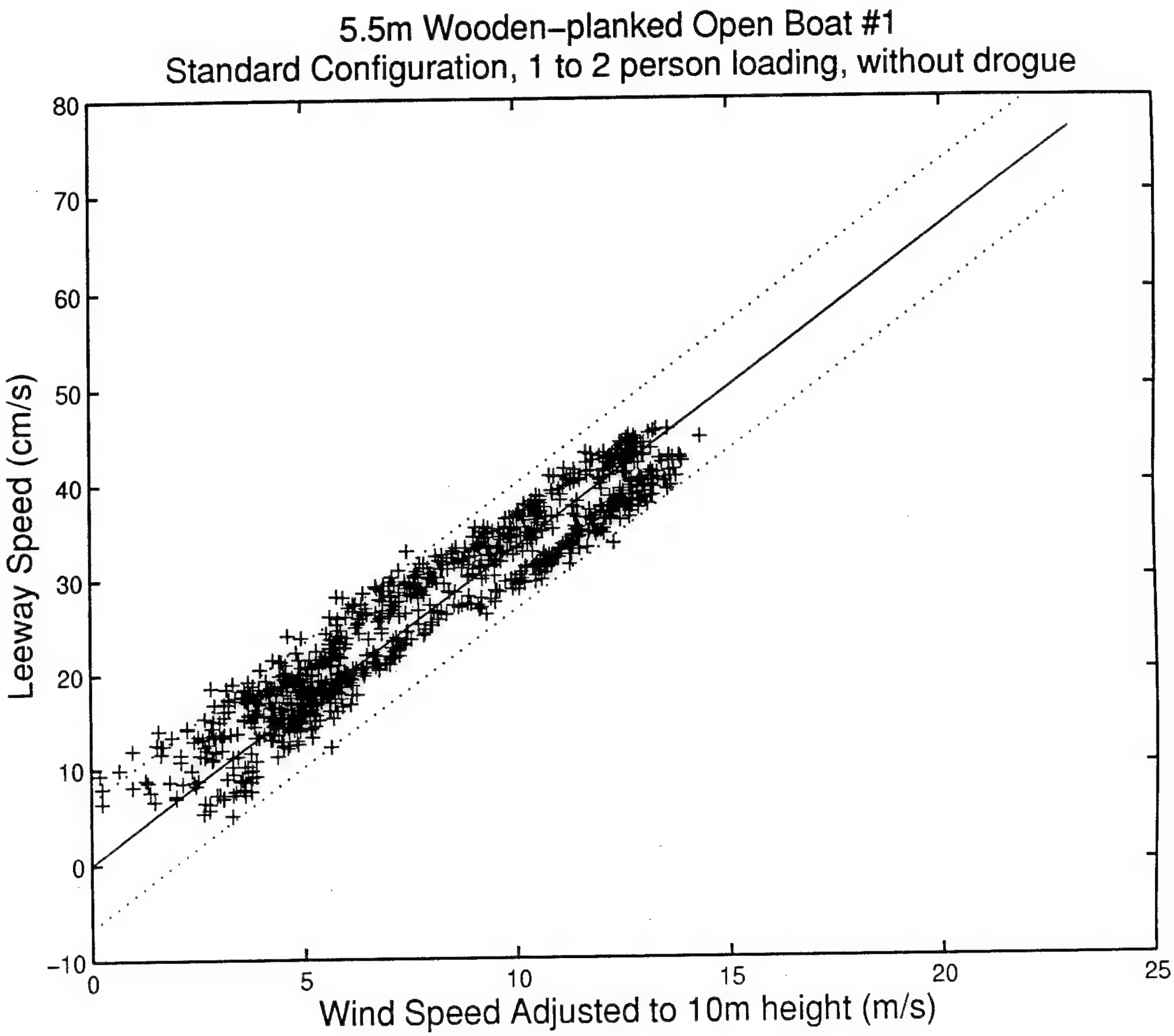


Figure 4-9. The Constrained Linear Regression and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat #1, Previous 7 Runs

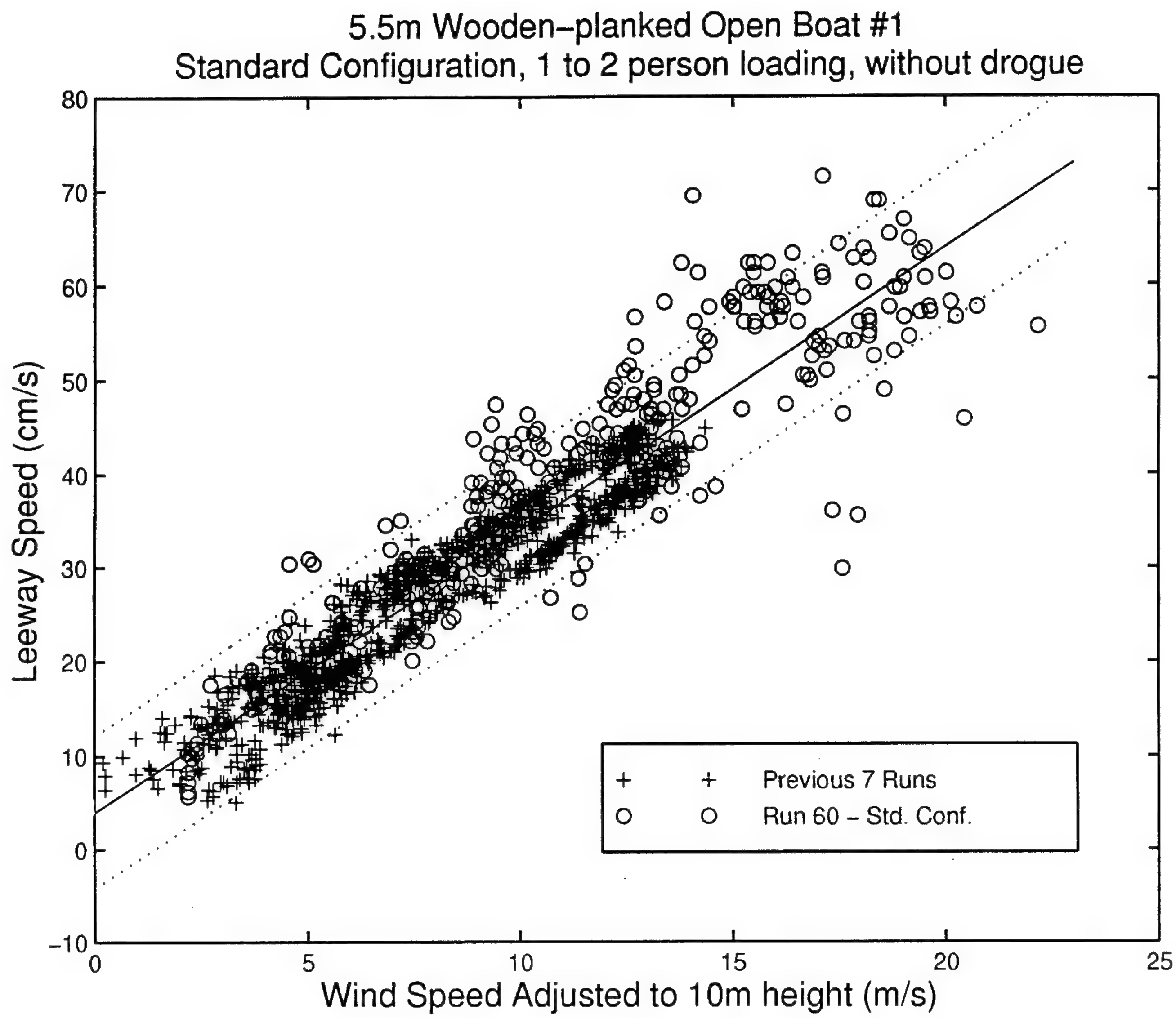


Figure 4-10. The Unconstrained Linear Regression and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat #1, Combined 8 Runs

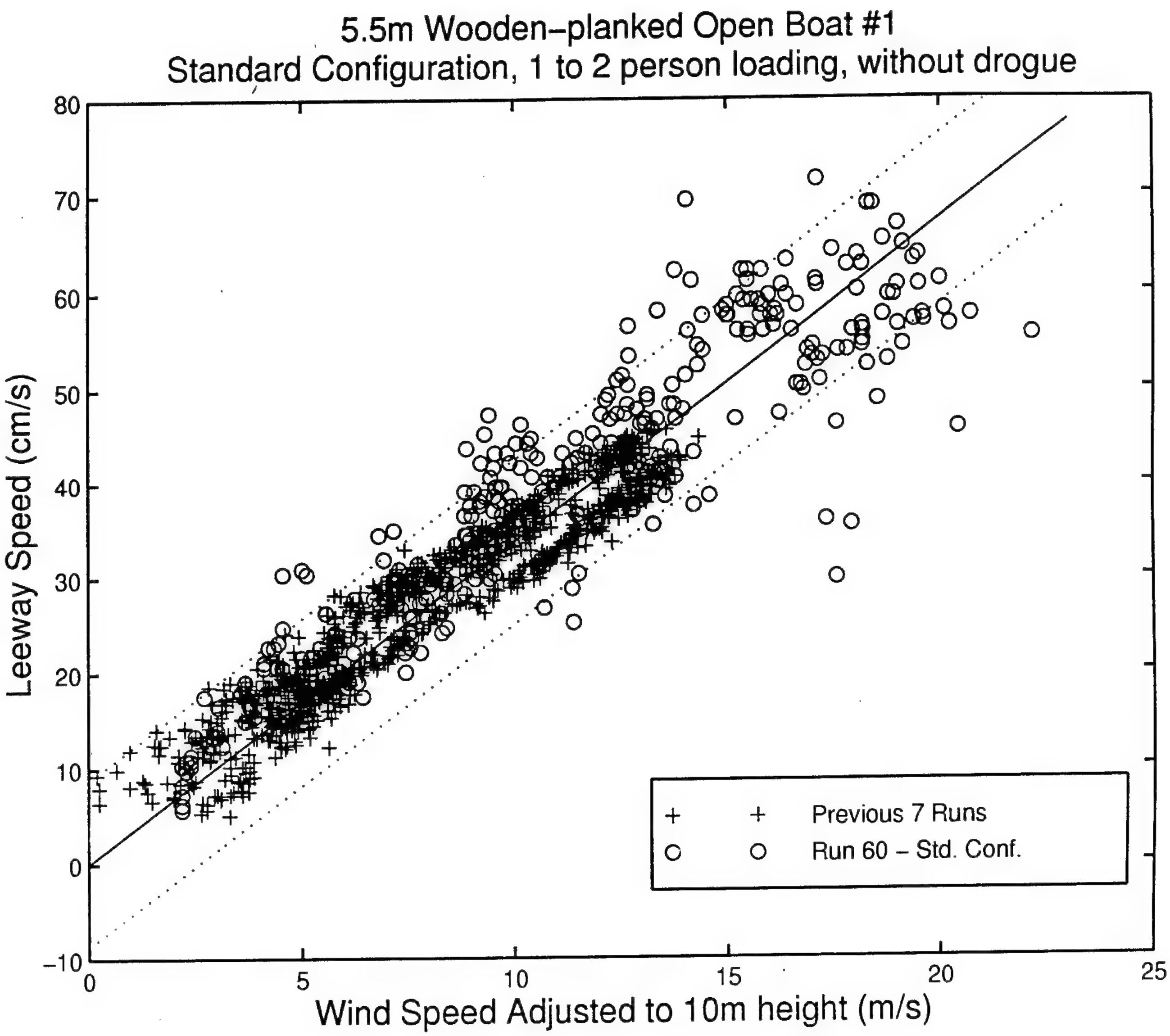


Figure 4-11. The Constrained Linear Regression and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat #1, Combined 8 Runs

4.2.2.2. Downwind and Crosswind Leeway Components

The downwind component of leeway (**DWL**) for open boat #1 is shown in Figures 4-12 and 4-13. The unconstrained (Figure 4-12) and the constrained linear regression (Figure 4-13) along with the 95% prediction limits are also shown. The regressions and 95% prediction limits are from the Combined 8 Runs. Tables 4-8 and 4-9 summarize the regressions and tables 4-10 and 4-11 summarize 95% prediction limits.

Table 4-8

Unconstrained Linear Regression of Downwind Component of Leeway (cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1
Standard Configuration

| Dependent Variable | Leeway Run | # | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| **DWL** | 60 - Std. Config. | 128 | 7.97 | 2.59 | 0.795 | 5.73 | 6.7 - 20.4 |
| **DWL** | Previous 7 | 1035 | 3.64 | 2.91 | 0.922 | 2.87 | 0.2 - 14.4 |
| **DWL** | Combined 8 | 1163 | 3.98 | 2.87 | 0.915 | 3.33 | 0.2 - 20.4 |

Table 4-9

Constrained Linear Regression of Downwind Component of Leeway(cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1
Standard Configuration

| Dependent Variable | Leeway Runs | # | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| **DWL** | 60- Std. Config. | 128 | 0.0 | 3.15 | 0.753 | 6.26 | 6.7 - 20.4 |
| **DWL** | Previous 7 | 1035 | 0.0 | 3.33 | 0.891 | 3.37 | 0.2 - 14.4 |
| **DWL** | Combined 8 | 1163 | 0.0 | 3.27 | 0.895 | 3.71 | 0.2 - 20.4 |

Table 4-10

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Unconstrained Linear Regression of Downwind Component of Leeway (cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1
Standard Configuration

| Leeway Runs | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1(W_{10m})^2$ | $c_2(W_{10m})$ | $c_3$ | $c_1(W_{10m})^2$ | $c_2(W_{10m})$ | $c_3$ |
| Run 60 - Std. Config. | 0.0023 | 2.53 | 19.73 | -0.0023 | 2.65 | -3.78 |
| Previous 7 | 0.0002 | 2.91 | 9.28 | -0.0002 | 2.92 | -2.01 |
| Combined 8 | 0.0002 | 2.87 | 10.53 | -0.0002 | 2.88 | -2.56 |

Table 4-11

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Constrained Linear Regression of Downwind Component of Leeway (cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1
Standard Configuration

| Leeway Runs | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1(W_{10m})^2$ | $c_2(W_{10m})$ | $c_3$ | $c_1(W_{10m})^2$ | $c_2(W_{10m})$ | $c_3$ |
| Run 60 - Std. Config. | 0.0003 | 3.15 | 12.39 | -0.0003 | 3.15 | -12.39 |
| Previous 7 | 0.0 | 3.33 | 6.62 | 0.0 | 3.33 | -6.62 |
| Combined 8 | 0.0 | 3.27 | 7.28 | 0.0 | 3.27 | -7.28 |

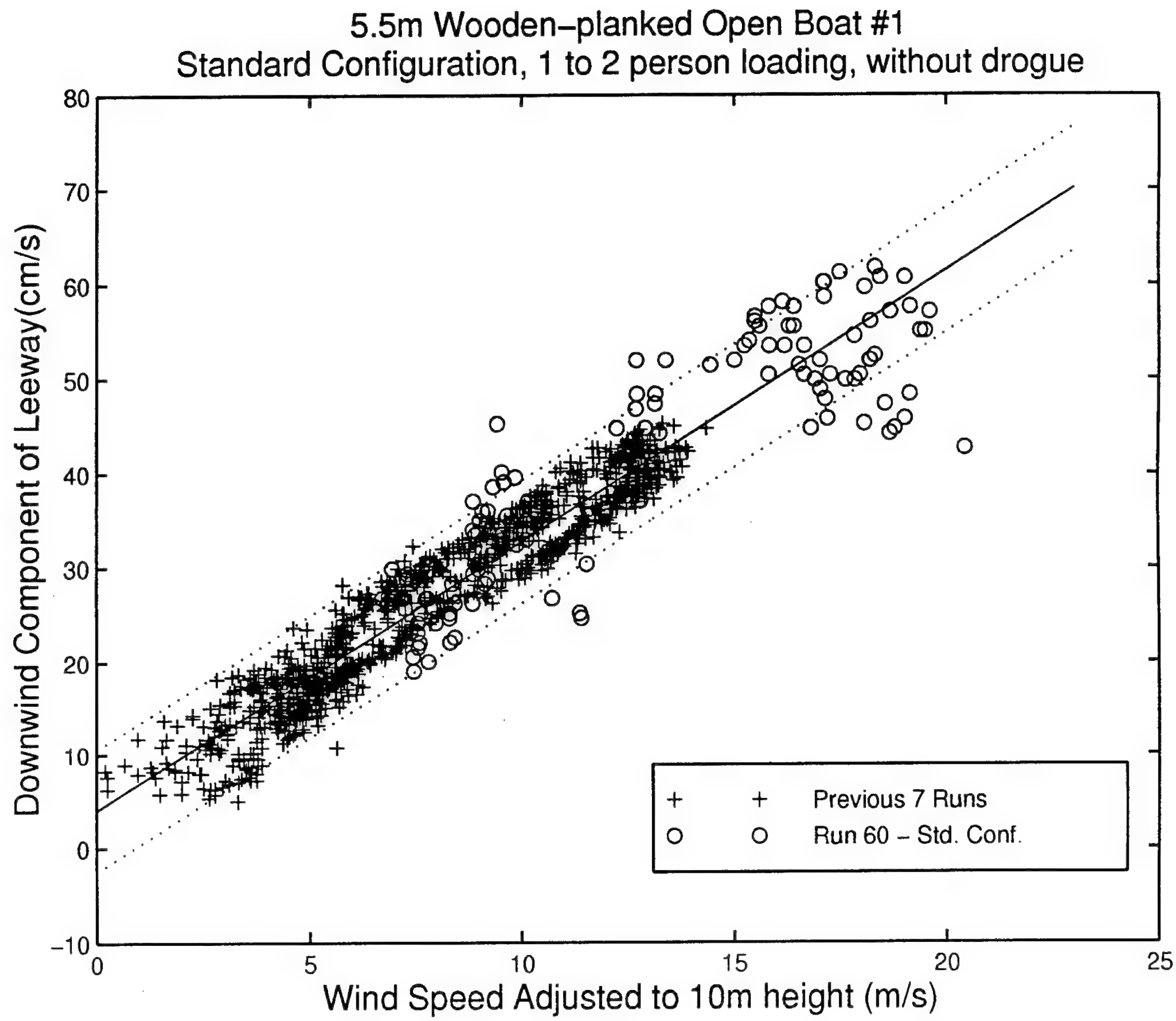


Figure 4-12. The Unconstrained Linear Regression and 95% Prediction Limits of the Downwind Component of Leeway versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat #1- Standard Configuration.

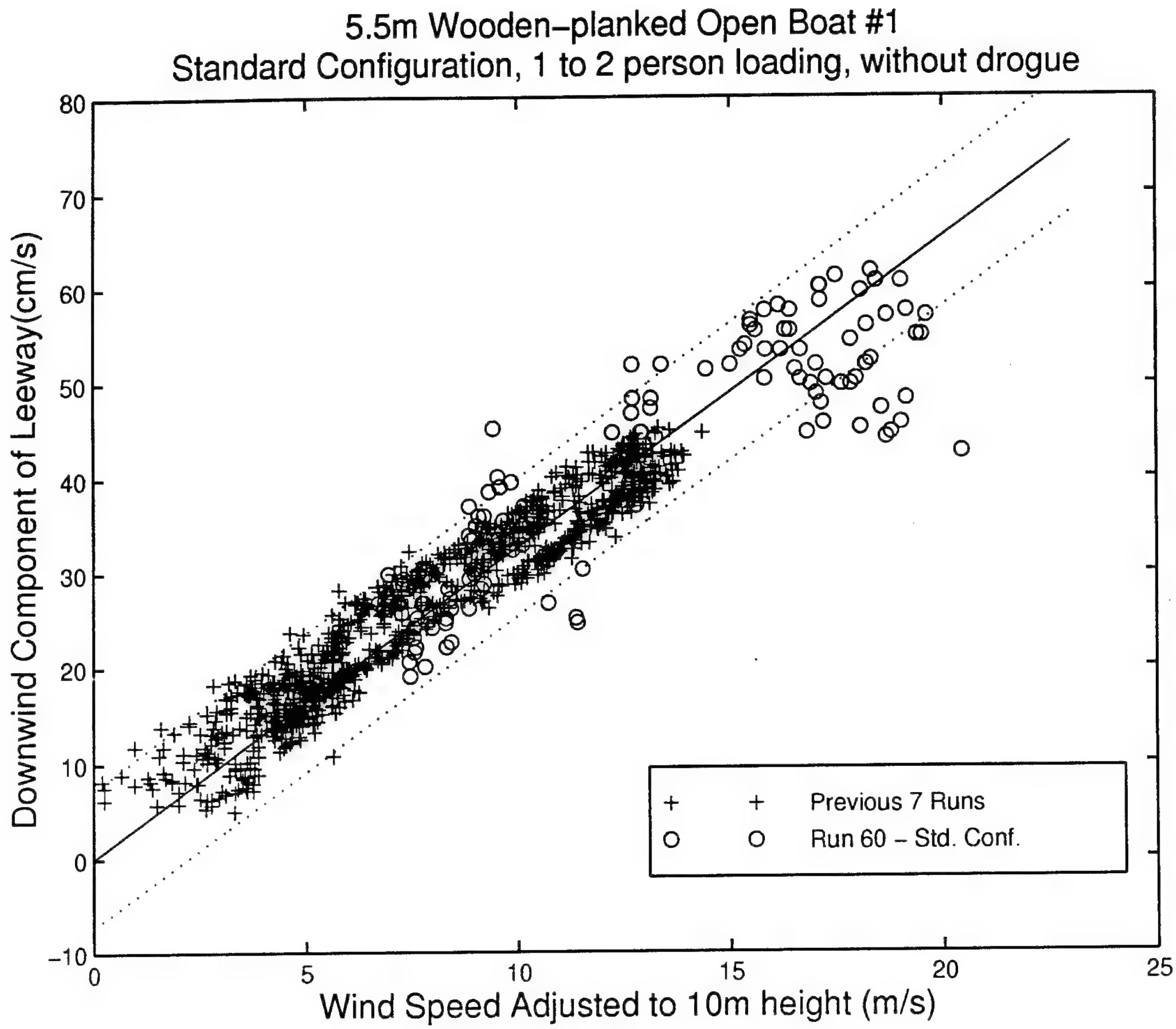


Figure 4-13. The Constrained Linear Regression and 95% Prediction Limits of the Downwind Component of Leeway versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat #1- Standard Configuration.

The crosswind components of leeway (**CWL**) versus wind speed for the Previous 7 Runs and for Run 60 are presented in Figure 4-14. Linear regressions, both unconstrained and constrained, of **CWL** are summarized in Table 4-12 and 4-13. Tables 4-14 and 4-15 summarize the 95% prediction limits.

The crosswind component of leeway contains both positive and negative values, thus linear regressions of the entire undifferentiated data set contain essentially no correlation ($r^2$ values near zero) with wind speed. Since **CWL** versus wind speed was a bi-modal data set, piece-wise regression analysis was conducted following the guidelines previously outlined in section 3.2.3. The piece-wise regression separated the crosswind components into two categories that reflected the boat's tendency to drift either to the right (positive **CWL**) or the left (negative **CWL**) of the downwind direction.

The five guidelines outlined in section 3.2.3 were used for piece-wise regression of the boat's **CWL** in the following manner. (1) Only data pairs from the Previous 7 Runs were used where the wind data was collected directly on-board the leeway test craft. The **CWL** values from Run 60 contained considerable scatter due to the wind data not being directly co-located and therefore were not considered valid data points. (2) All the data pairs of **CWL** and $\mathbf{W_{10m}}$ from the Previous 7 Runs were used, and used only once. (3) The division of data pairs was based upon the values of Relative Wind Direction. Relative Wind Direction as defined in section 3.1 can range from -180 to +180 degrees, as the wind comes over the port then starboard side the boat as shown in Figure 4-15. The data pairs of **CWL** and $\mathbf{W_{10m}}$ were sorted into two groups; those with relative wind direction between -180 and 0 degrees (wind from the port) and those between 0 and +180 degrees (wind from the starboard) as shown in Figure 4-16. (4) Linear unconstrained and constrained regressions were then performed on these two groups of data pairs, as shown in Figures 4-17, 4-18 and 4-19. (5) The final recombination is based upon the piecewise use of the unconstrained linear regressions as shown in Figure 4-20. Table 4-12 presents the coefficients of the regression equations and Table 4-14 contains the coefficients of the 95 percent confidence limits. The recombination model uses the negative regression for winds speeds from zero to 15 m/s and uses the positive regression for winds speeds above 4.2 m/s, the intercept of the two regression lines. At wind speeds above 4.2 m/s the boat jibbed between the positive and negative values of **CWL**.

Table 4-12

Unconstrained Linear Regression of Crosswind Component of Leeway (cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1
Standard Configuration

| Dependent Variable | Leeway Run | # | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| **CWL** | 60 - Std. Config. | 128 | -19.54 | 0.79 | 0.044 | 16.02 | 6.7 - 20.4 |
| **CWL** | Previous 7 | 1035 | -1.21 | -0.05 | 0.003 | 3.56 | 0.2 - 14.4 |
| **CWL** | Combined 8 | 1163 | -0.90 | -0.20 | 0.011 | 6.90 | 0.2 - 20.4 |
| **+(CWL)** | Previous 7 (Neg. Rel. Wind Dir.) | 679 | -2.93 | 0.32 | 0.15 | 2.53 | 0.2 - 14.4 |
| **-(CWL)** | Previous 7 (Pos. Rel. Wind Dir.) | 356 | 1.03 | -0.62 | 0.35 | 3.05 | 1.5 - 13.6 |

Table 4-13
Constrained Linear Regression of Crosswind Component of Leeway(cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1
Standard Configuration

| Dependent Variable | Leeway Run | # | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| **CWL** | 60 - Std. Config. | 128 | 0.0 | -0.59 | -0.11 | 17.17 | 6.7 - 20.4 |
| **CWL** | Previous 7 | 1035 | 0.0 | -0.18 | -0.02 | 3.59 | 0.2 - 14.4 |
| **CWL** | Combined 8 | 1163 | 0.0 | -0.28 | 0.009 | 6.91 | 0.2 - 20.4 |
| **+ (CWL)** | Previous 7 (Neg. Rel. Wind Dir.) | 679 | 0.0 | 0.004 | -0.02 | 2.77 | 0.2 - 14.4 |
| **- (CWL)** | Previous 7 (Pos. Rel. Wind Dir.) | 356 | 0.0 | -0.52 | .333 | 3.07 | 1.5 - 13.6 |

Table 4-14

The Coefficients of the Polynomials Describing 95% Prediction Limits of the Unconstrained Linear Regression of Crosswind Component of Leeway (cm/s) on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1- Standard Configuration
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Dependent Variable | Leeway Runs | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|---|
| | | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| **CWL** | Run 60 - Std. Config. | 0.0064 | 0.627 | 13.35 | -0.0064 | 0.955 | -52.43 |
| **CWL** | Previous 7 | 0.0003 | -0.059 | 5.79 | -0.0003 | -0.049 | -8.21 |
| **CWL** | Combined 8 | 0.0004 | -0.202 | 12.67 | -0.0004 | -0.188 | -14.47 |
| **+(CWL)** | Previous 7 (Neg. Rel. Wind Dir.) | 0.0003 | 0.317 | 2.06 | -0.0003 | 0.328 | -7.91 |
| **-(CWL)** | Previous 7 (Pos. Rel. Wind Dir.) | 0.0007 | -0.634 | 7.08 | -0.0007 | -0.612 | -5.01 |

Table 4-15

The Coefficients of the Polynomials Describing 95% Prediction Limits of the Constrained Linear Regression of Crosswind Component of Leeway (cm/s) on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1- Standard Configuration
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Dependent Variable | Leeway Runs | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|---|
| | | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| **CWL** | Run 60 - Std. Config. | 0.0007 | -0.590 | 33.97 | -0.0007 | -0.590 | -33.97 |
| **CWL** | Previous 7 | 0.0 | -0.184 | 7.04 | 0.0 | -0.184 | -7.04 |
| **CWL** | Combined 8 | 0.0001 | -0.284 | 13.55 | -0.0001 | -0.284 | -13.55 |
| **+ (CWL)** | Previous 7 (Neg. Rel. Wind Dir.) | 0.0001 | 0.004 | 5.44 | -0.0001 | 0.004 | -5.44 |
| **- (CWL)** | Previous 7 (Pos. Rel. Wind Dir.) | 0.0001 | -0.515 | 6.04 | -0.0001 | -0.515 | -6.04 |

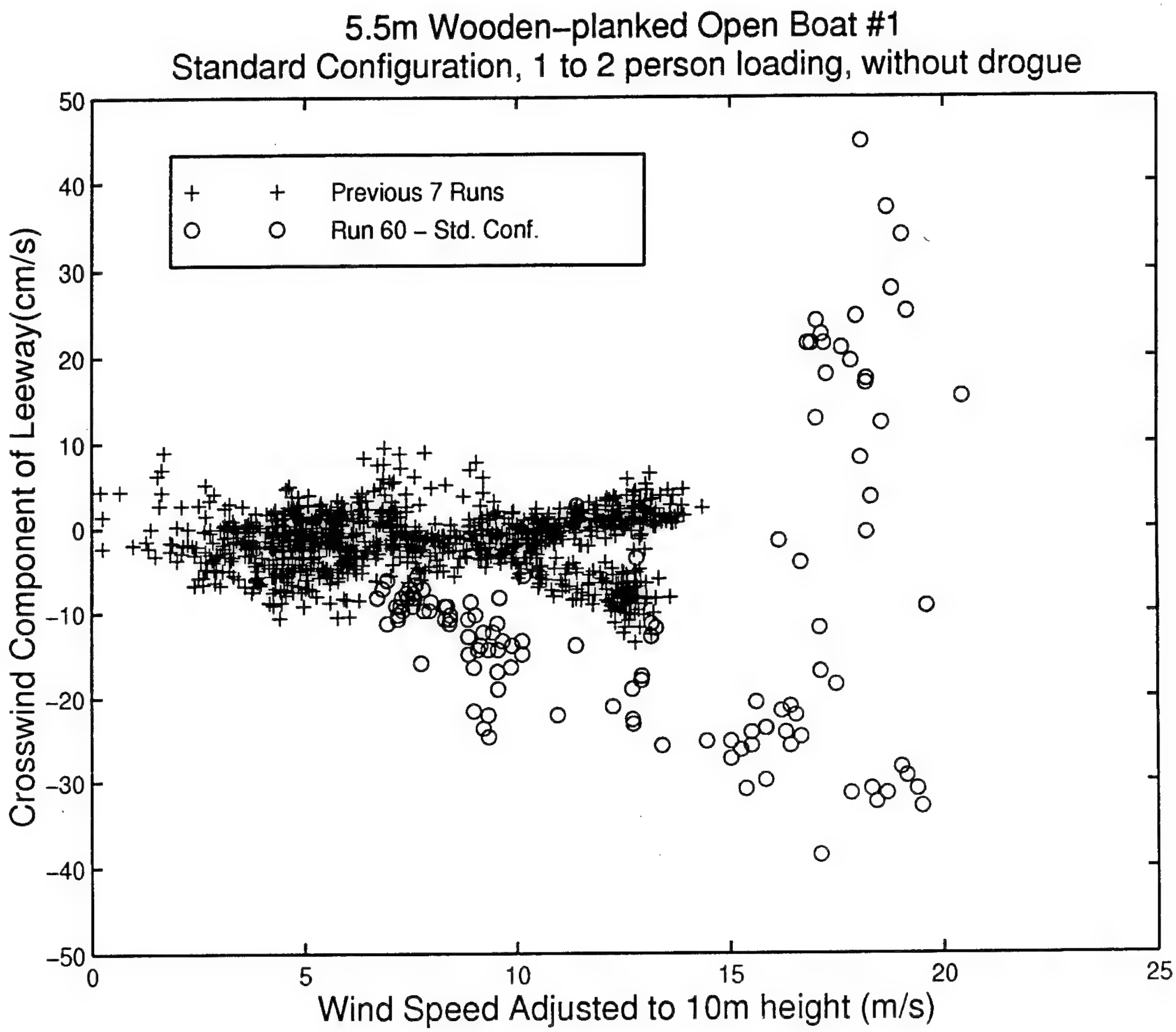


Figure 4-14. The Crosswind Component of Leeway versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat #1. Crosses (+) are data from the Previous 7 Runs, and circles (o) are data from Run 60 - Standard Configuration.

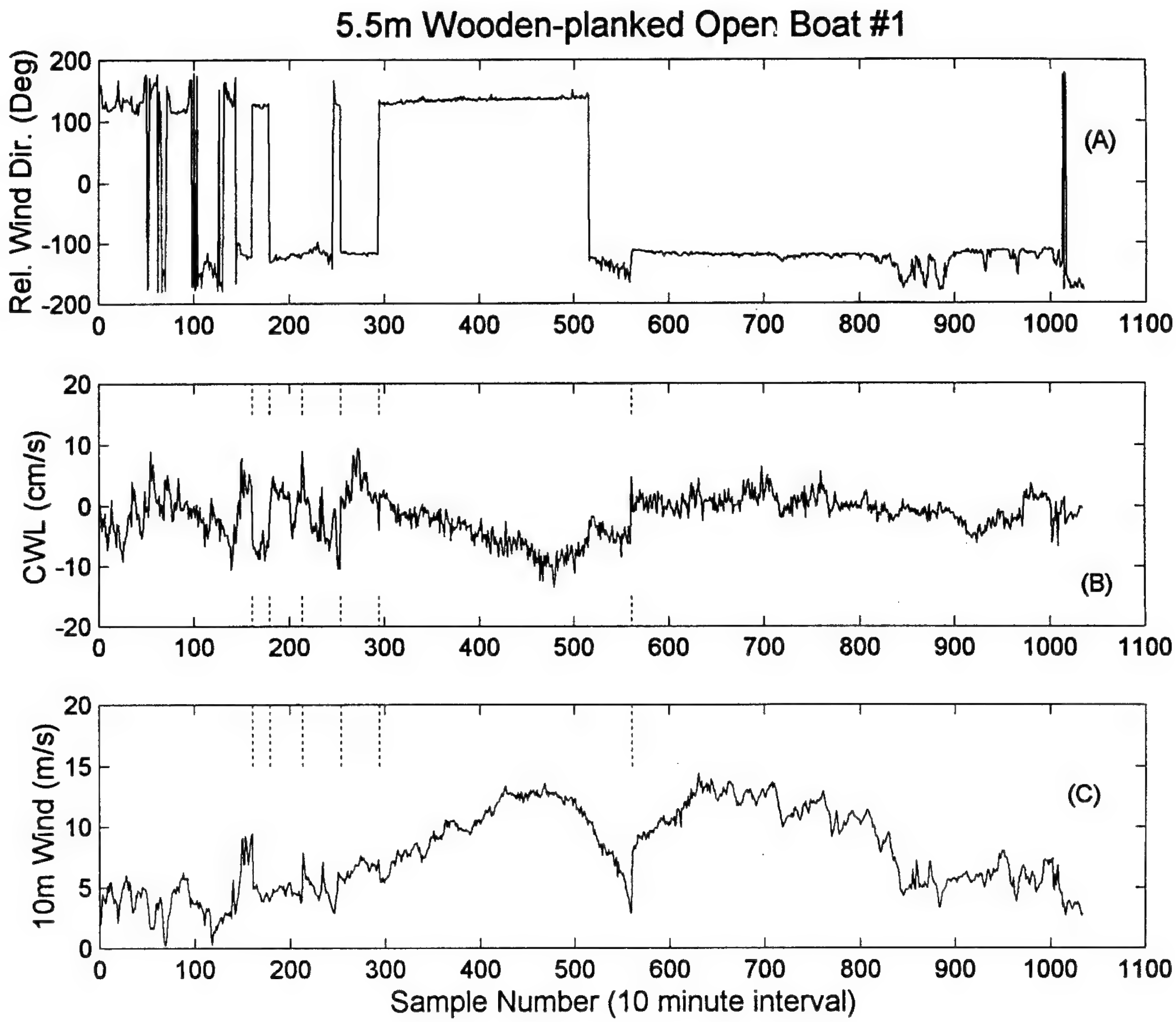


Figure 4-15. The sequential series from the 7 Previous Runs of the 5.5m Wooden-Planked Open Boat #1 of (A) Relative Wind Direction, (B) Crosswind Component of Leeway and (C) Wind Speed at 10m. Run separations are marked with vertical dashed lines.

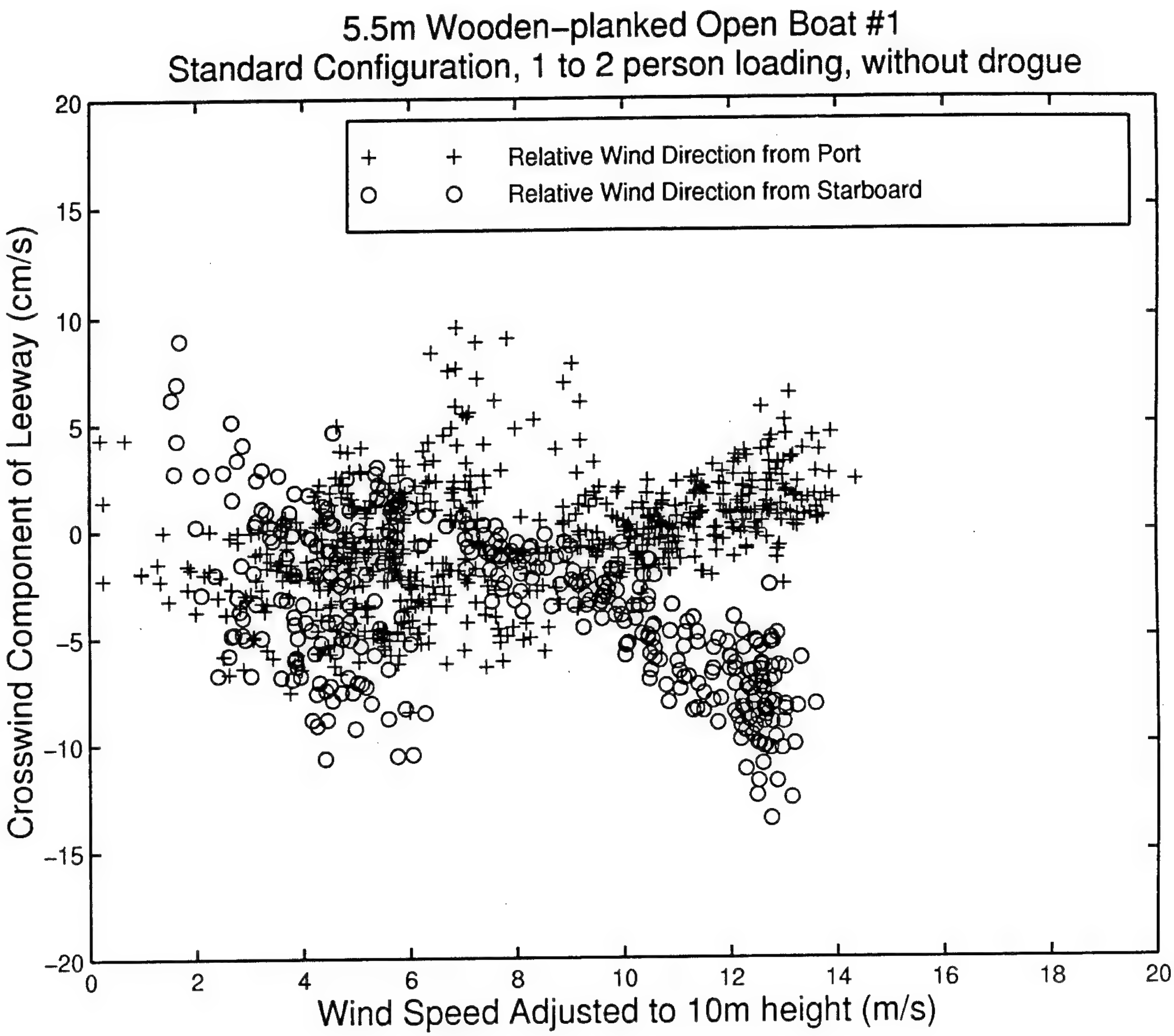


Figure 4-16. The Crosswind Component of Leeway versus Wind Speed at 10m separated by Relative Wind Direction, 5.5m Wooden-Planked Open Boat #1, 7 Previous Runs.

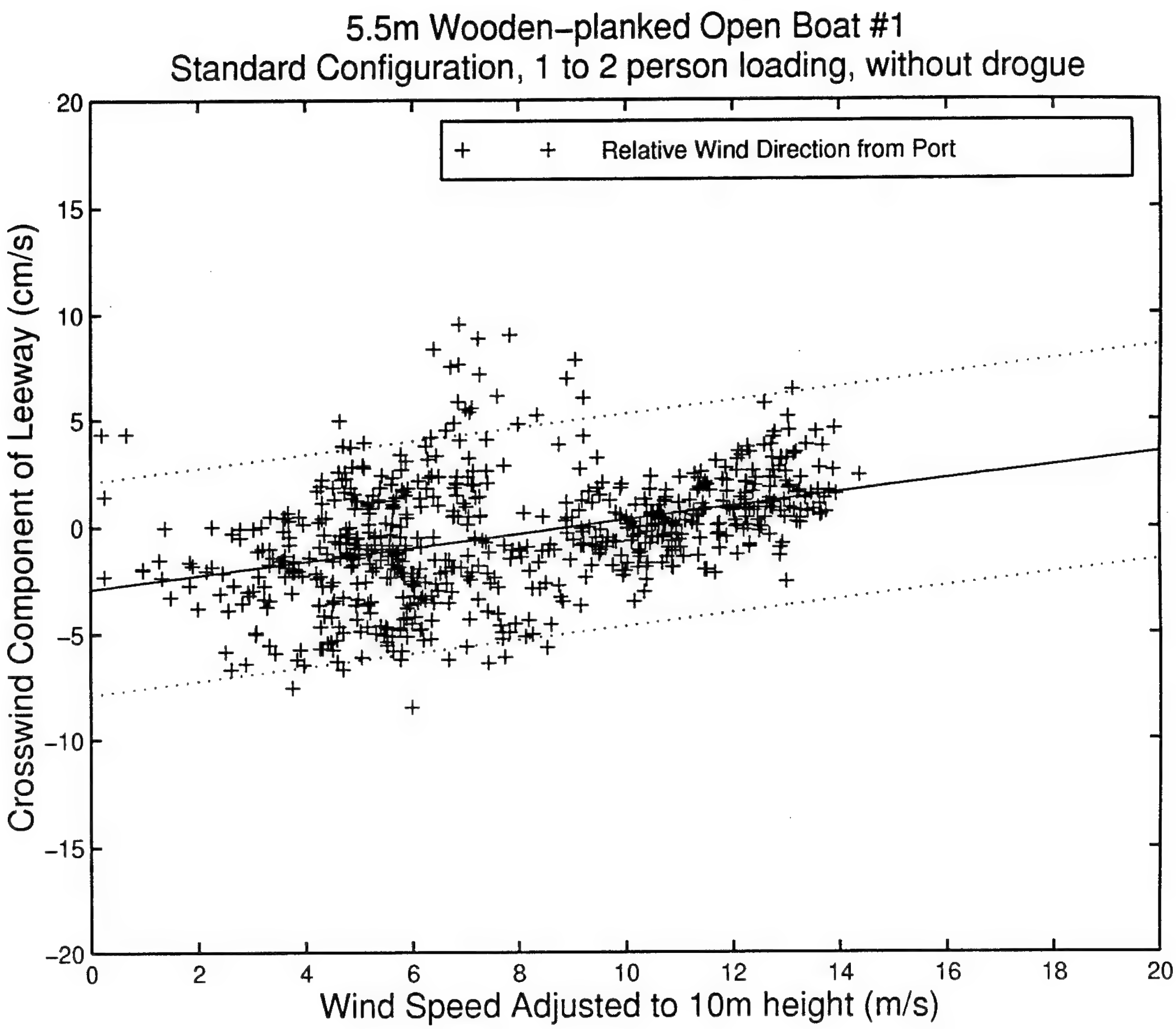


Figure 4-17. The Unconstrained Linear Regression and 95% Prediction Limits of Crosswind Component of Leeway versus Wind Speed at 10m separated by Negative Relative Wind Direction, 5.5m Wooden-Planked Open Boat #1, 7 Previcus Runs.

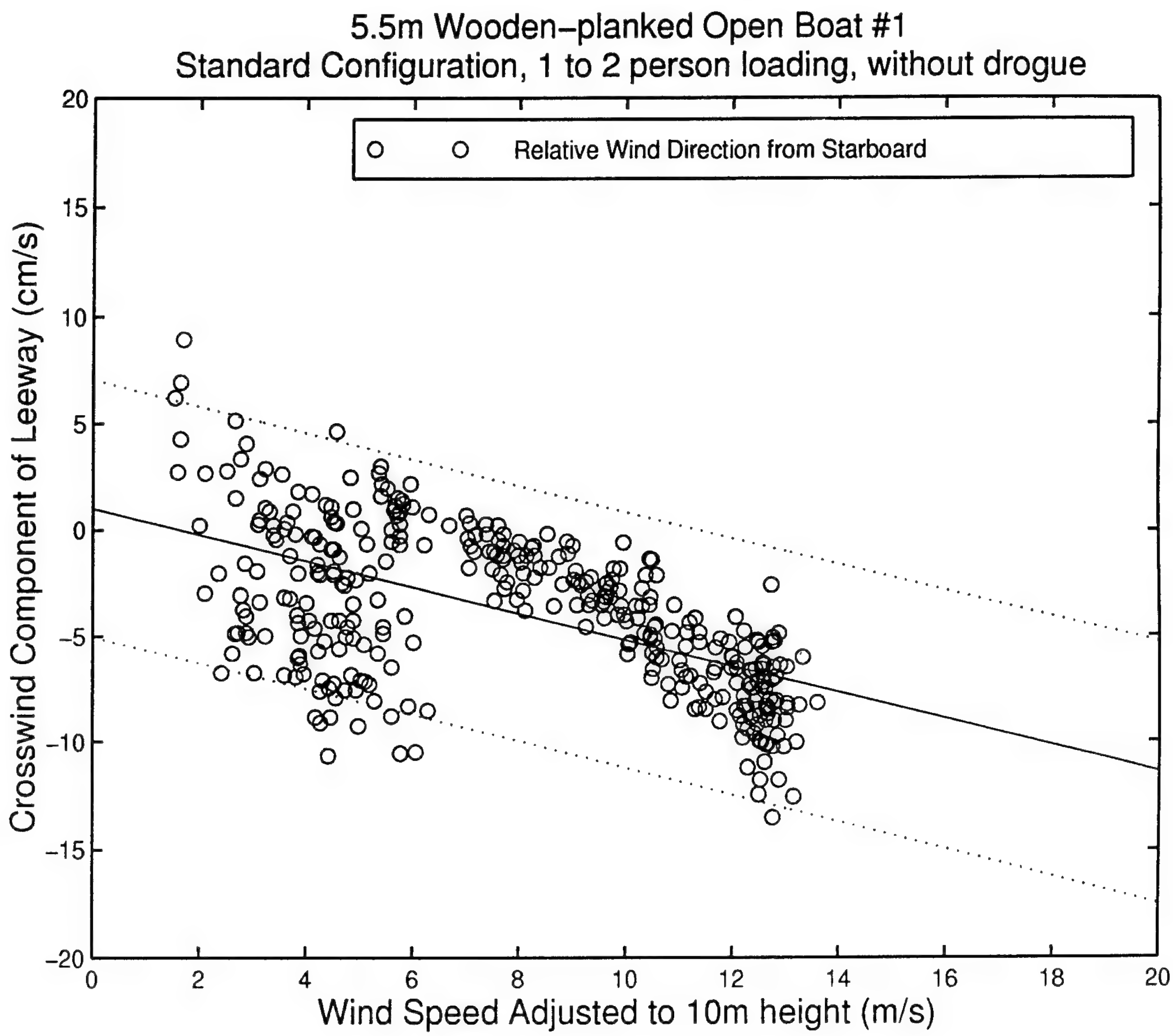


Figure 4-18. The Unconstrained Linear Regression and 95% Prediction Limits of Crosswind Component of Leeway versus Wind Speed at 10m separated by Positive Relative Wind Direction, 5.5m Wooden-Planked Open Boat #1, 7 Previous Runs.

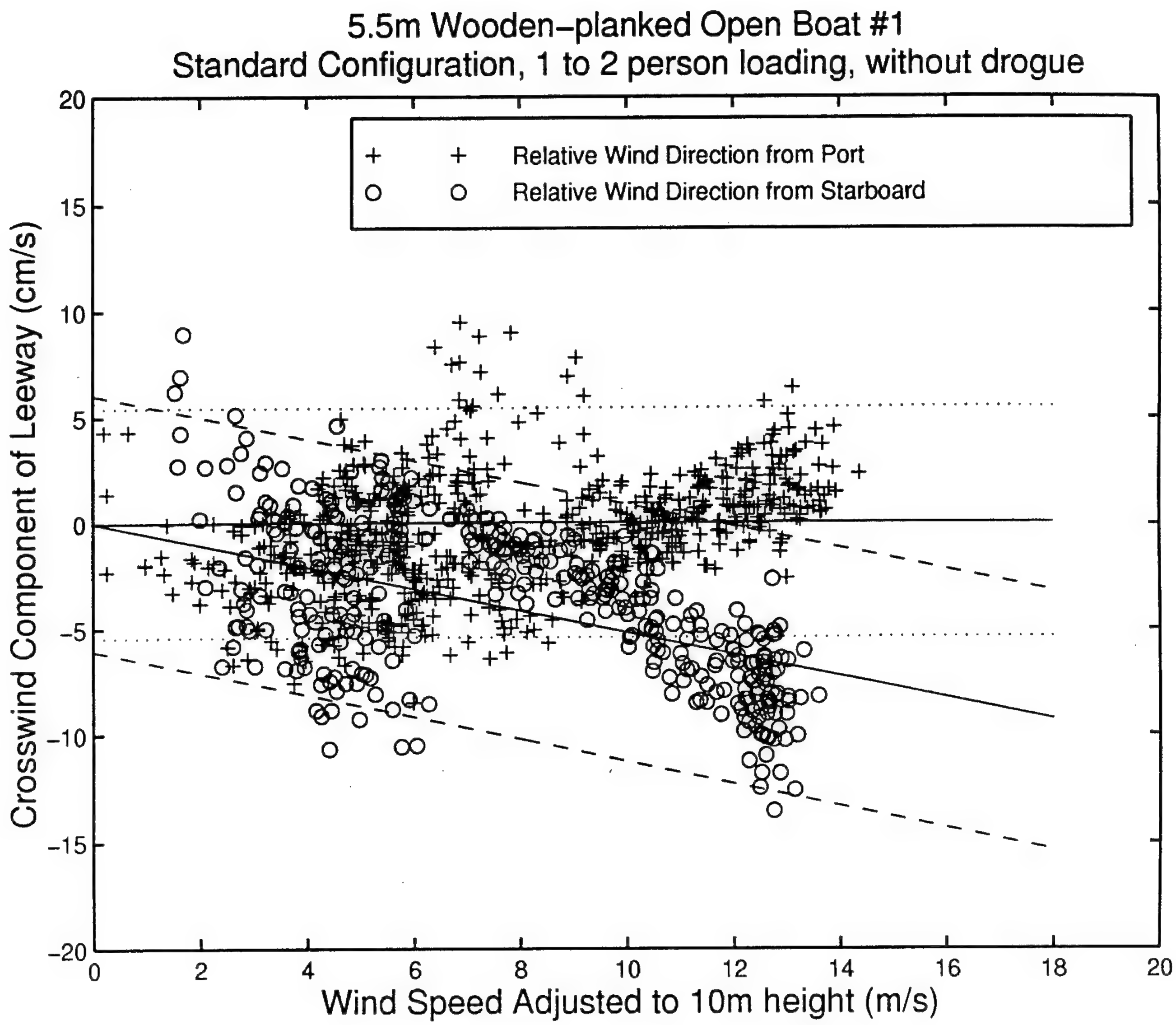


Figure 4-19. The Constrained Linear Regression and 95% Prediction Limits of Crosswind Component of Leeway versus Wind Speed at 10m separated by Positive and Negative Relative Wind Directions, 5.5m Wooden-Planked Open Boat #1, 7 Previous Runs.

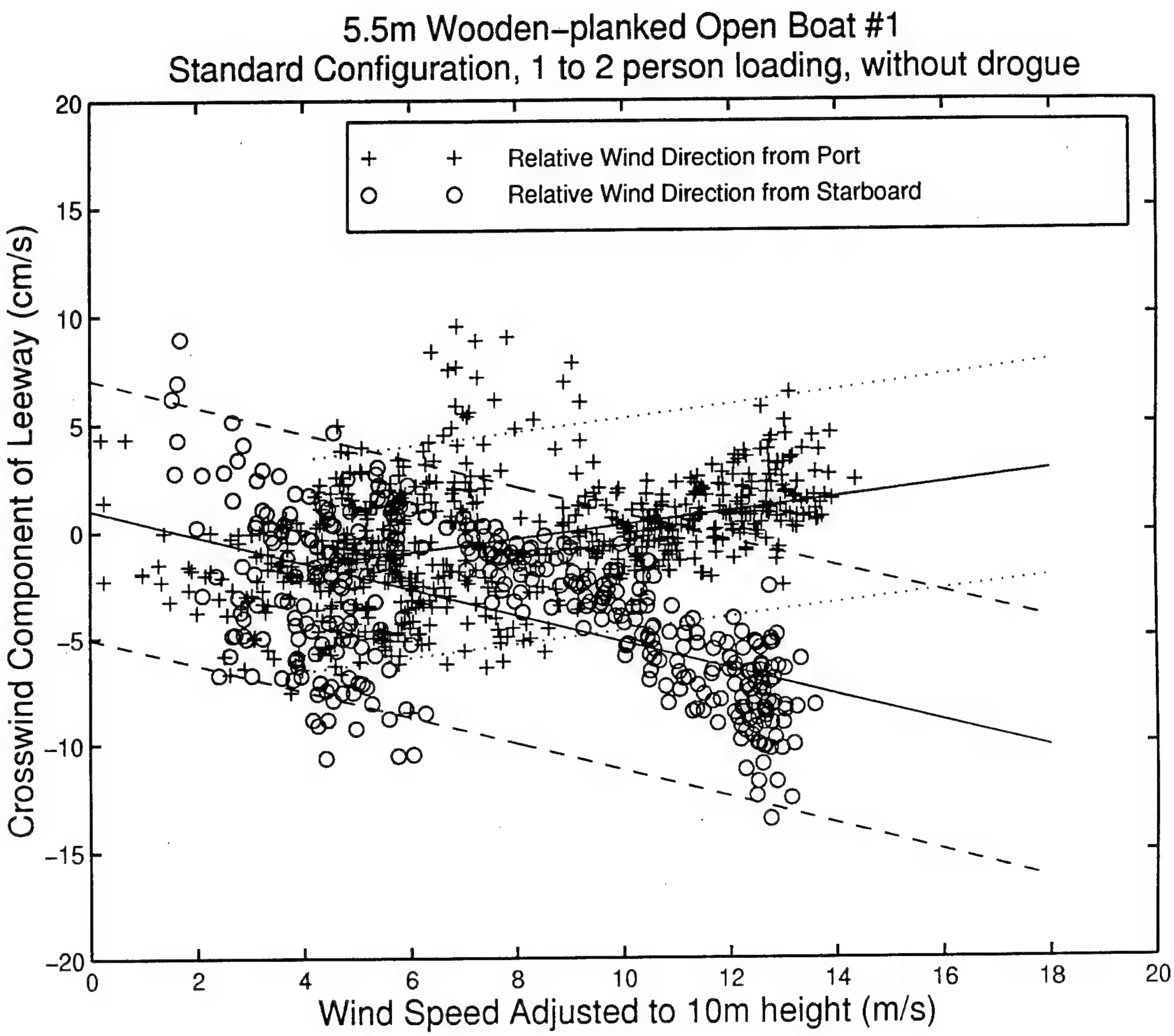


Figure 4-20. The Piece-Wise Unconstrained Linear Regression model and 95% Prediction Limits of Crosswind Component of Leeway versus Wind Speed at 10m separated by Positive and Negative Relative Wind Directions, 5.5m Wooden-Planked Open Boat #1, 7 Previous Runs.

4.2.2.3 Relative Wind Direction and Jibbing

Since search planners have no knowledge of the relative wind direction of an actual open boat in distress, guidance is required to estimate the frequency of shifting between the two possible **CWL** regression lines and their associated 95% prediction limits presented in the previous section. Therefore in this section, the relative wind direction from the 7 Previous Runs is summarized and related to frequency of the boat jibbing. Relative wind direction data collected during the 7 Previous Runs were based upon a single measurement at the end of each 10-minute sample. Since the boat passes its stern through the wind and not its bow, changing from a positive to negative relative wind direction or vice-versa is referred to as jibbing. Relative wind direction is summarized in Table 4-16. When relative wind direction is sorted into negative values (wind coming across the port side of the boat) and positive values (wind coming over the starboard side) it is apparent that the boat had two stable orientations to wind, one with wind crossing the aft port quarter and the second with wind crossing the aft starboard quarter. The relative wind direction remained between -98 degrees and 111 degrees as shown in Figure 4-21.

Table 4-16
Relative Wind Direction (degrees)
5.5m Wooden-Planked Open Boat #1 - Standard Configuration

| Leeway | # | $W_{10m}$ | Relative Wind Direction (Degrees) | | | | Abs. Relative Wind Direction | |
|---|---|---|---|---|---|---|---|---|
| Run | samples | (m/s) | mean | s.dev. | min | max | mean | s.dev. |
| Previous 7 | 1035 | 0.2 - 14.4 | -36.8 | 125.4 | -180 | 179 | 129.6 | 15.8 |
| Previous 7 (wind from Port) | 679 | 0.2 - 14.4 | -126.8 | 16.9 | -180 | -98 | 126.8 | 16.9 |
| Previous 7 (wind from Starboard) | 356 | 1.5 - 13.6 | 135.0 | 11.7 | 111 | 179 | 135.0 | 11.7 |

The times at which the boat changed from one stable orientation to the other had to be determined to estimate the frequency of jibbing. Jibbing was assumed to have occurred when Relative Wind Direction changed from a value greater than + 90 degrees to a value less than -90 degrees or vice-versa. Because the sequence presented in Figure 4-15 (A) was used, four of the twenty-six jibes when relative wind direction sign changed occurred between sequential leeway drift runs. The boat did not jibe during any portion of three short runs out of the seven total runs. Fifty percent of the time the change in relative wind direction from one stable orientation to the other (jibbing) occurred at periods less than 65 minutes and 95 percent of time the jibbing occurred within a period of 46 hours. The cumulative percentile of the frequency of jibbing based upon the 26 jibes is presented in Figure 4-21.

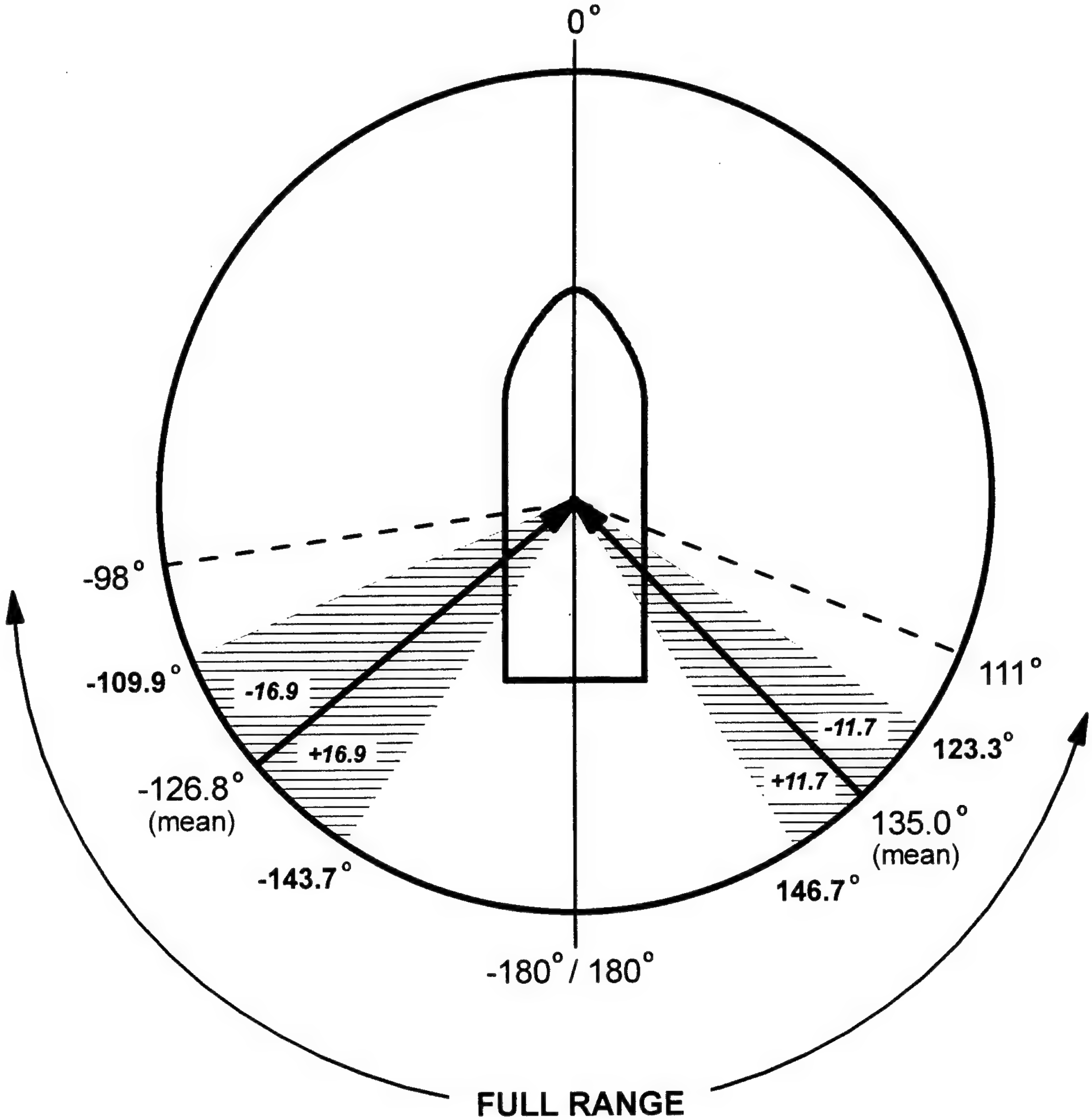


Figure 4-21. The Mean, Standard Deviation and Range of Positive and Negative Relative Wind Directions, 5.5m Wooden-Planked Open Boat #1 Standard Configuration, 7 Previous Runs.

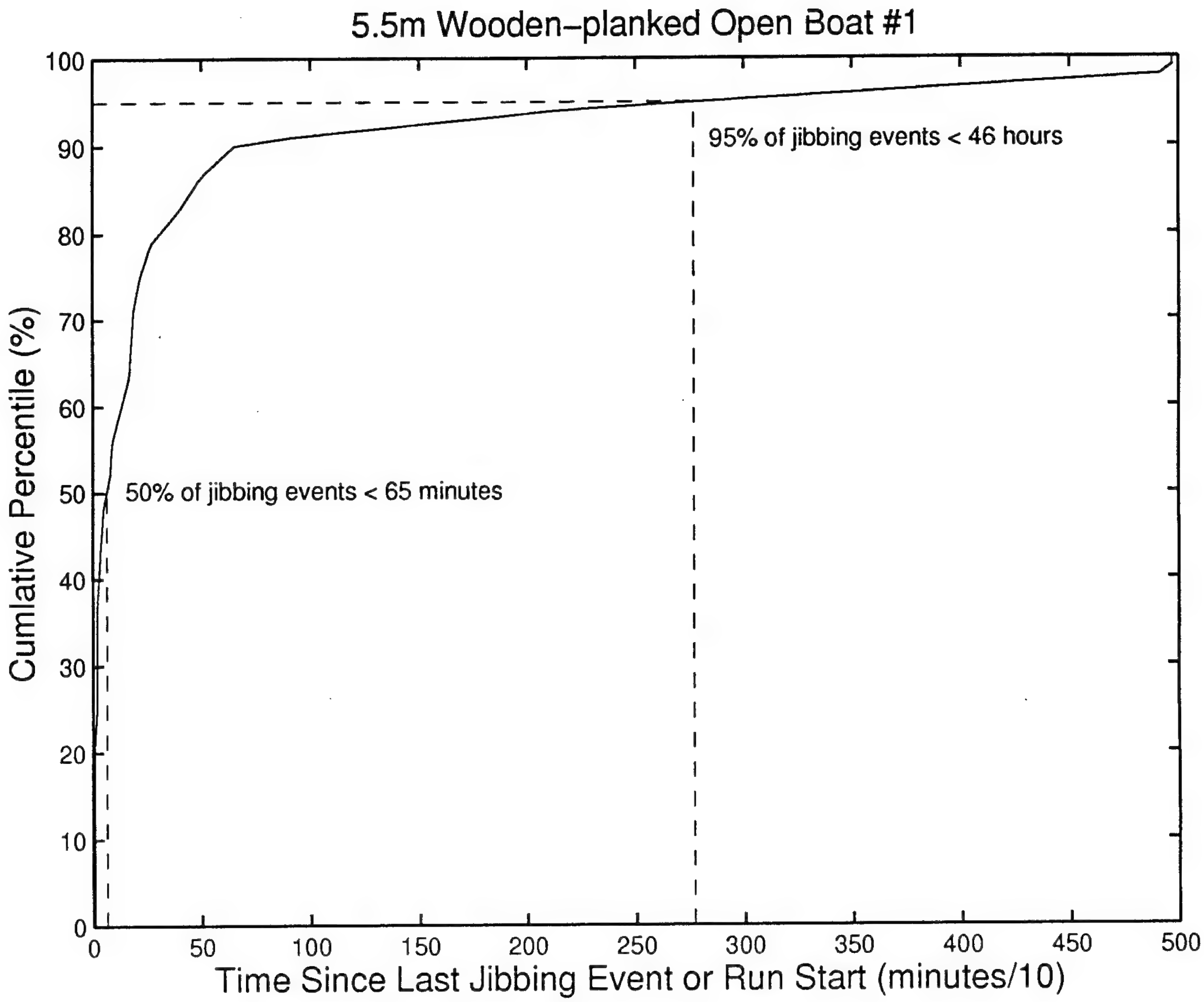


Figure 4-22. Cumulative Percentile of the Frequency of Jibbing Events (Change-in-Sign of Relative Wind Direction) as a Function of Elapsed Time Since Last Jibbing Event or Run Start, 5.5m Wooden-Planked Open Boat #1, 7 Previous Runs.

### 4.2.3 The Leeway of Swamped 5.5m open boat #1

Boat #1 swamped at 22:45 UTC on yearday 332, 1995 and remained swamped unit it was recovered 67 hours and 20 minutes later at yearday 335 17:55 UTC. There were 404 10-minute leeway data points for the open boat #1 Run 60 - Swamped. During this period neither the onboard GPS positioning data logger nor the Argos positioning system was working, therefore only a crude estimate can be made that the craft was within 50 km of the MiniMet® buoy. The boat was not instrumented with pitch and roll sensors, so there were no direct measurements of its vertical orientation. Also, during this period, the onboard wind data were lost and the wind direction data from the MiniMet® buoy had been corrupted. Because the wind data were limited to wind speed, and not wind direction, the analysis below was limited to computation of leeway rate and leeway speed. In spite of these limitations, this data set is currently the only one available on the leeway of a swamped boat.

#### 4.2.3.1 Leeway Rate and Speed

The leeway rate of the swamped boat #1 was based upon 404 data points from the time the boat swamped at 332 22:45 UTC and when it was recovered at 335 17:55 UTC. The mean leeway rate for the open boat #1 Run 60 - Swamped was 1.73% with a standard deviation of 0.46%, and a range of 0.6% to 2.7%. The mean leeway rate for the Swamped Boat was 47% that of the Standard Configuration open boat as shown in Table 4-3.

Figure 4-23 shows time series for the values of (A) 10m wind speed, (B) leeway speed and (C) leeway rate. During the first portion of the leeway rate record the rate was very low and then at yearday 333 15:55 UTC the leeway rate rose to intermediate levels. It is postulated that the boat capsized at 332 22:45 and remained capsized until 333 15:55 when it rolled over again and remained in the upright but swamped position until it was spotted and recovered at 335 17:55 UTC. Therefore the **assumption** is that the data record is divided into two sub - categories: during the first portion of the record the open boat #1 was swamped and capsized, and during the second portion the open boat #1 was swamped and upright. Figure 4-24 shows the two sub-categories as a function of wind speed. Table 4-17 summarizes the leeway rate for the open boat #1: Swamped and Capsized; Swamped and Upright; and the combined undifferentiated category - Swamped.

The leeway rate of the open boat #1 - Swamped and Capsized was based upon 103 data points from the time the boat swamped at 332 22:45 UTC and when it was assumed to roll back upright at 333 15:55. The mean leeway rate for the open boat #1 Run 60 - Swamped and Capsized was 1.12% with a standard deviation of 0. 18 %, and a range of 0.6% to 1.7%.

The leeway rate of the open boat #1 - Swamped and Upright was based upon 301 data points from the time the boat was assumed to roll back upright at 333 15:55 until it was recovered at 335 17:55 UTC.. The mean leeway rate for the open boat #1 Run 60 - Swamped and Upright was 1.94% with a standard deviation of 0. 31 %, and a range of 1.0% to 2.8%.

Table 4-17

Leeway Rate (Percent of $\mathbf{W}_{10m}$)
5.5m Wooden-Planked Open Boat #1

| Leeway Run 60 | # samples | Leeway Rate mean | s.dev. | min | max |
|---|---|---|---|---|---|
| Swamped and Capsized | 103 | 1.12 | 0.18 | 0.6 | 1.7 |
| Swamped and Upright | 301 | 1.94 | 0.31 | 1.0 | 2.8 |
| Swamped | 404 | 1.73 | 0.46 | 0.6 | 2.8 |

The time series of the leeway speed of the 5.5m Swamped open boat #1 along with the wind speeds adjusted to 10-meter height are shown in Figure 4-23 (A and B). What is unusual about this leeway speed record is the apparent lack of a relationship with the wind speed. Assuming that the boat was first swamped and capsized and then rolled over and remained swamped, then the leeway values versus $\mathbf{W}_{10m}$ data [Figures 4-24 (leeway rate versus $\mathbf{W}_{10m}$) and 4-25 (leeway speed versus $\mathbf{W}_{10m}$) ] shows that the leeway speed values separate into two groupings. With data separation based upon this assumption the leeway speed of the swamped and capsized open boat is linearly dependent ($r^2 = 0.388$ for the unconstrained regression, see Table 4-18 and as shown in Figure 4-25) on the $\mathbf{W}_{10m}$, while the Swamped and Upright open boat has no dependence ($r^2 = 0.0$ for the unconstrained regression) on the wind speed.

Analysis method was then limited (see section 3.2.1 for analysis hierarchy) to constrained linear regression of the portion of data record for the boat swamped and assumed upright, as reported in Tables 4-18 and 19 and as shown in Figure 4-25. The coefficient of determination ($r^2$) is negative, which means that the constrained linear regression contained greater spread about the mean than the spread of the raw values about the mean value of the data (mean leeway speed of swamped and assumed upright open boat was 17.9 cm/s). This suggests that using the mean leeway rate is the appropriate statistical method to describe this particular leeway data set. The mean leeway rate for the swamped and assumed upright open boat was 1.94 percent of the $\mathbf{W}_{10m}$, as shown in Table 4-17.

The leeway speed of the swamped boat did not show any dependence on significant wave height, ($r^2 = 0.027$ for the unconstrained linear regression of leeway speed and significant wave height from the MiniMet buoy).

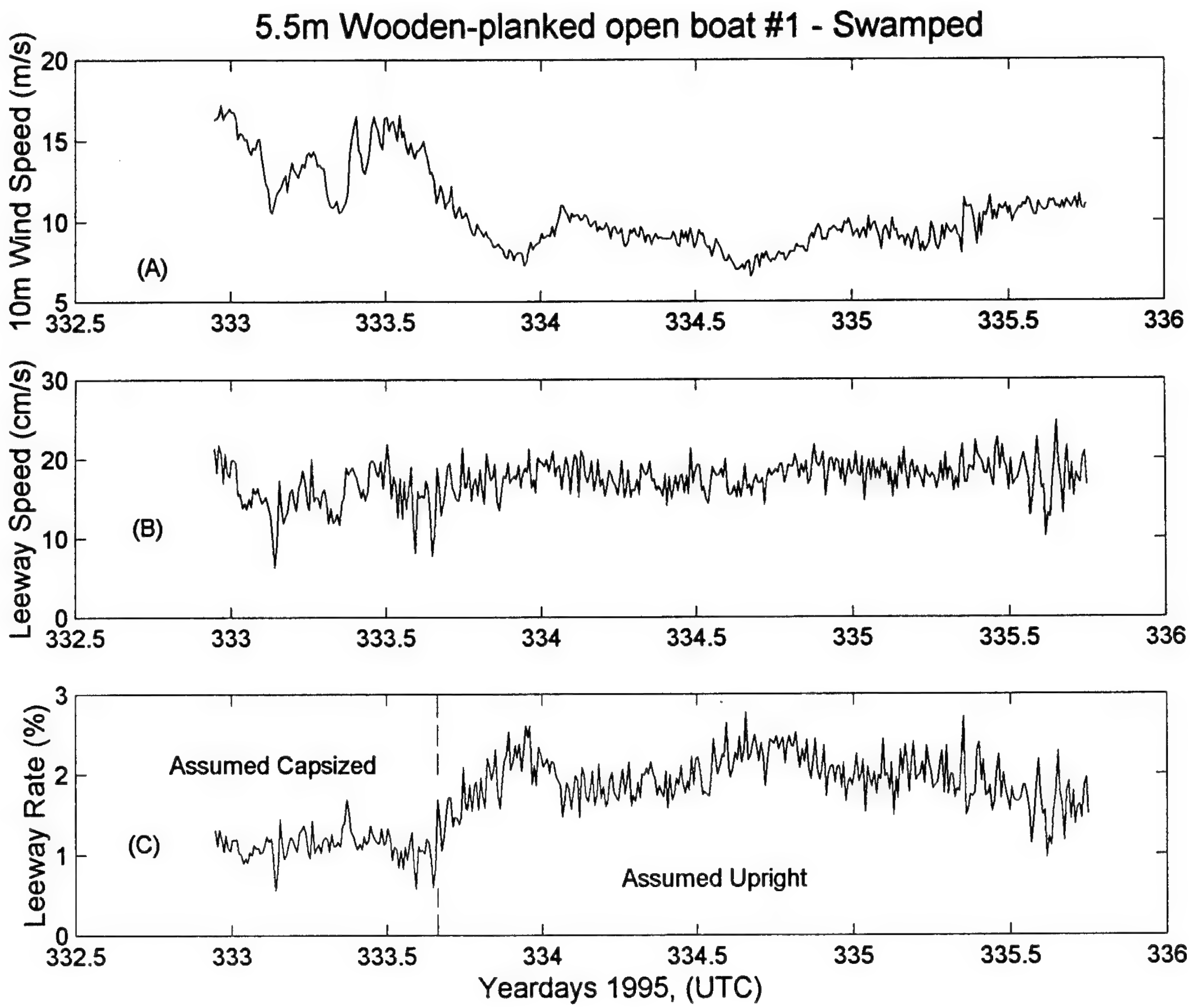


Figure 4-23. Time Series of (A) the 10m Wind Speed (m/s) and (B) the Leeway Speed (cm/s) and (C) Leeway Rate (Percent) of the Swamped 5.5m Wooden-Planked Open Boat #1.

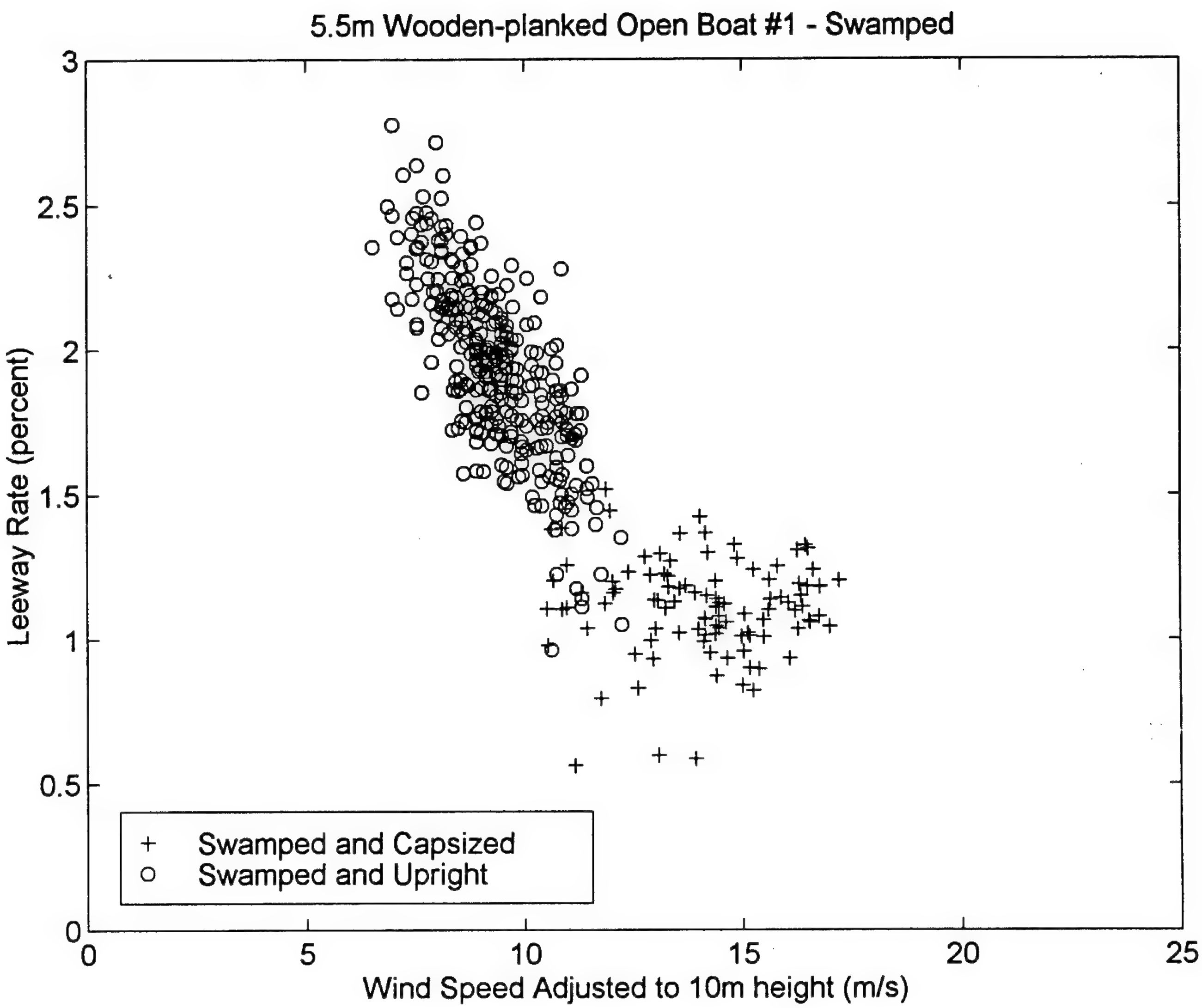


Figure 4-24. Leeway Rate versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat, Leeway Run 60 - Swamped and assumed either Capsized or Upright.

Table 4-18

Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1 - Swamped

| Dependent Variable | Leeway Run 60 | # | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| Leeway Speed (Unconstrained) | Swamped and Capsized | 103 | 0.9 | 1.05 | 0.388 | 2.35 | 10.5 - 17.2 |
| Leeway Speed (Constrained) | Swamped and Upright | 301 | 0.0 | 1.88 | -1.19 | 2.90 | 6.5 - 12.2 |
| Leeway Speed (Unconstrained) | Swamped | 404 | 19.3 | -0.19 | 0.034 | 2.42 | 6.5 - 17.2 |

Table 4-19

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
5.5m Wooden-Planked Open Boat #1 - Swamped
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Leeway Runs | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| Swamped and Capsized (Unconstrained) | 0.0052 | 0.88 | 6.85 | -0.0052 | 1.22 | -5.09 |
| Swamped and Upright (constrained) | 0.0001 | 1.88 | 5.71 | -0.0001 | 1.88 | -5.71 |
| Swamped (unconstrained) | 0.0010 | -0.21 | 24.19 | -0.0010 | -0.17 | 14.45 |

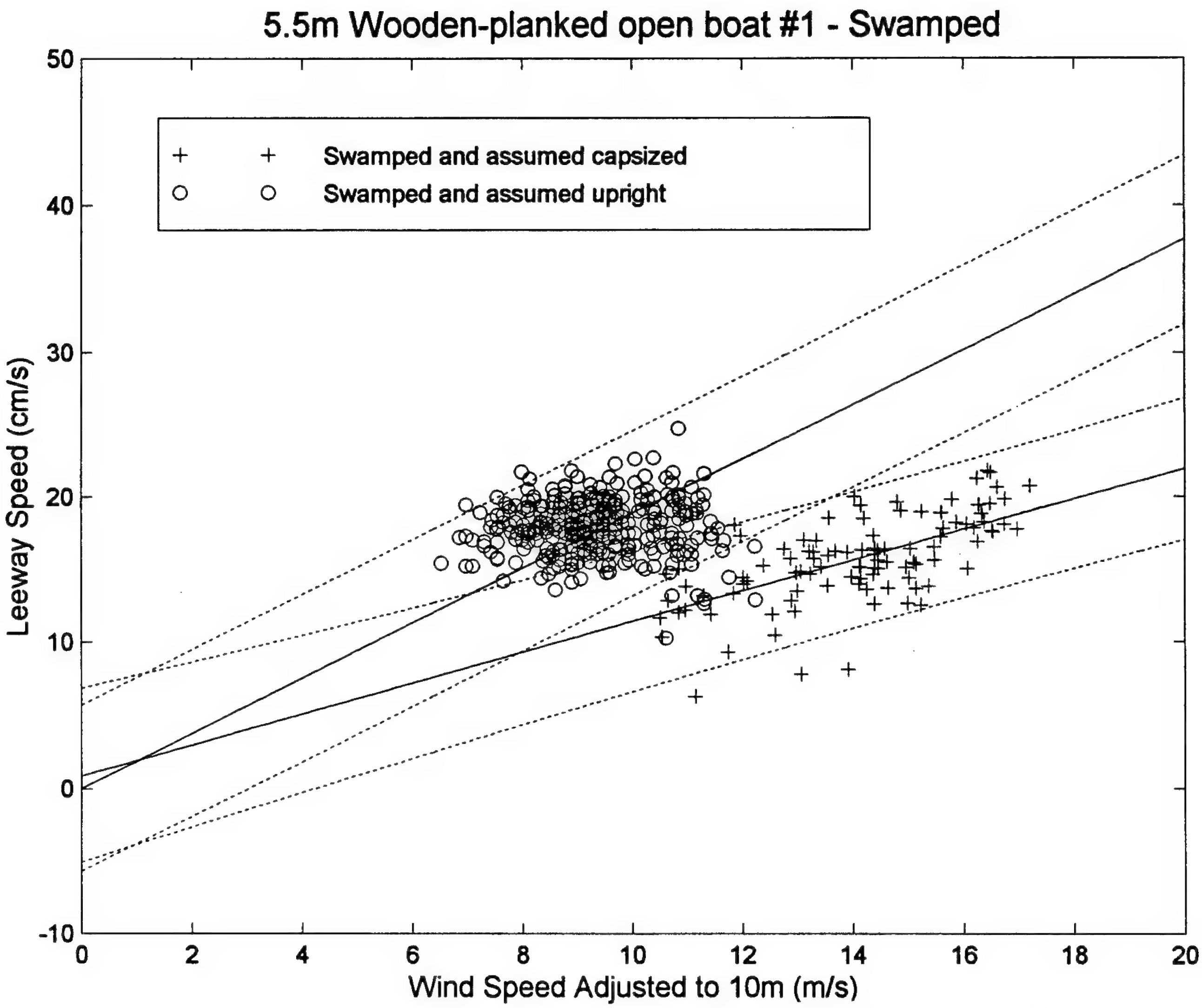


Figure 4-25. Leeway Speed versus Wind Speed at 10m, 5.5m Wooden-Planked Open Boat, Leeway Run 60 - Swamped and assumed either Swamped or Capsized. The constrained linear regression and 95% prediction limits of the leeway speed versus wind speed for boat swamped and assumed upright (circles) is shown along with the unconstrained linear regression and 95% prediction limits for the boat swamped and assumed capsized (crosses).

### 4.3 SWITLIK 6-PERSON LIFE RAFT "J" with FULL TOROIDAL BALLAST BAG

Leeway run # 63 started when Switlik 6-Person life raft "J" was deployed at 20:22 UTC on 25 November 1995. Data for this raft consist of 710 ten-minute averages collected during the last 4.93 days of the 5.7 day drift. The 10 meter wind speed ranged from 2.2 to 22.2 m/s, with significant wave heights of 1.5 to 9.3 meters. Life raft "J" was deployed with a drogue and had loading equivalent to 1 person.

When life raft "J" was recovered on 1 December 1995 at 13:30 UTC, it was missing the wind monitoring system and the GPS receiver/antenna. The raft's canopy had collapsed and the raft was filled with water. The S4® EMCM and its float were alongside the raft, instead of the usual alignment where the S4® EMCM and its float are upwind of the leeway craft. Therefore, the leeway craft changed phase from a Standard Configuration life raft to a swamped life raft with a collapsed canopy. Before the record was divided into two parts, an estimate had to be made as to when the raft swamped and its canopy collapsed.

Previous studies of the Switlik 6-Person life raft "J" are limited to a single 4.8 hour drift of the Sea Rescue Kit, Fitzgerald et al. (1994). The Sea Rescue Kit configuration is three Switlik 6-Person life rafts and two survival packs attached together by 300m of line. For this study life raft "J" was considered to be a leeway target type separate from the Sea Rescue Kit.

#### 4.3.1 The Swamping of Switlik 6-Person Life Raft "J"

The time series of leeway rate, figure 4-26, clearly shows that the leeway rate fell below 1.0 percent at 22:25 UTC on yearday 332, (time 332.93) and remained below 1.0 percent until life raft "J" was recovered. The data records for life raft "J" were therefore divided into two subsets; before 22:25 UTC, yearday 332 and after that time. During the first time segment, the life raft was considered to be in the "Standard Configuration" and during the second segment it was considered "swamped." The life raft's canopy was "intact" during the first segment and 'collapsed" during the second segment. Table 4-20 presents the summary of the environmental conditions which prevailed during the two time segments.

Table 4-20
Summary of Data for the Switlik 6-Person Life Raft "J"

| CRAFT | LEEWAY RUN | Data (hh:mm) | $\mathbf{W_1}$ $(m/s)_{0m}$ | Significant Wave Height (m) |
|---|---|---|---|---|
| Switlik 6-Person life raft "J" | Total | 118.20 | 2.2 - 22.2 | 1.5 - 9.3 |
| | Std.. Config. | 55:30 | 2.2 - 22.2 | 1.5 - 9.3 |
| | Swamped | 62:50 | 6.5 - 17.2 | 3.0 - 6.9 |

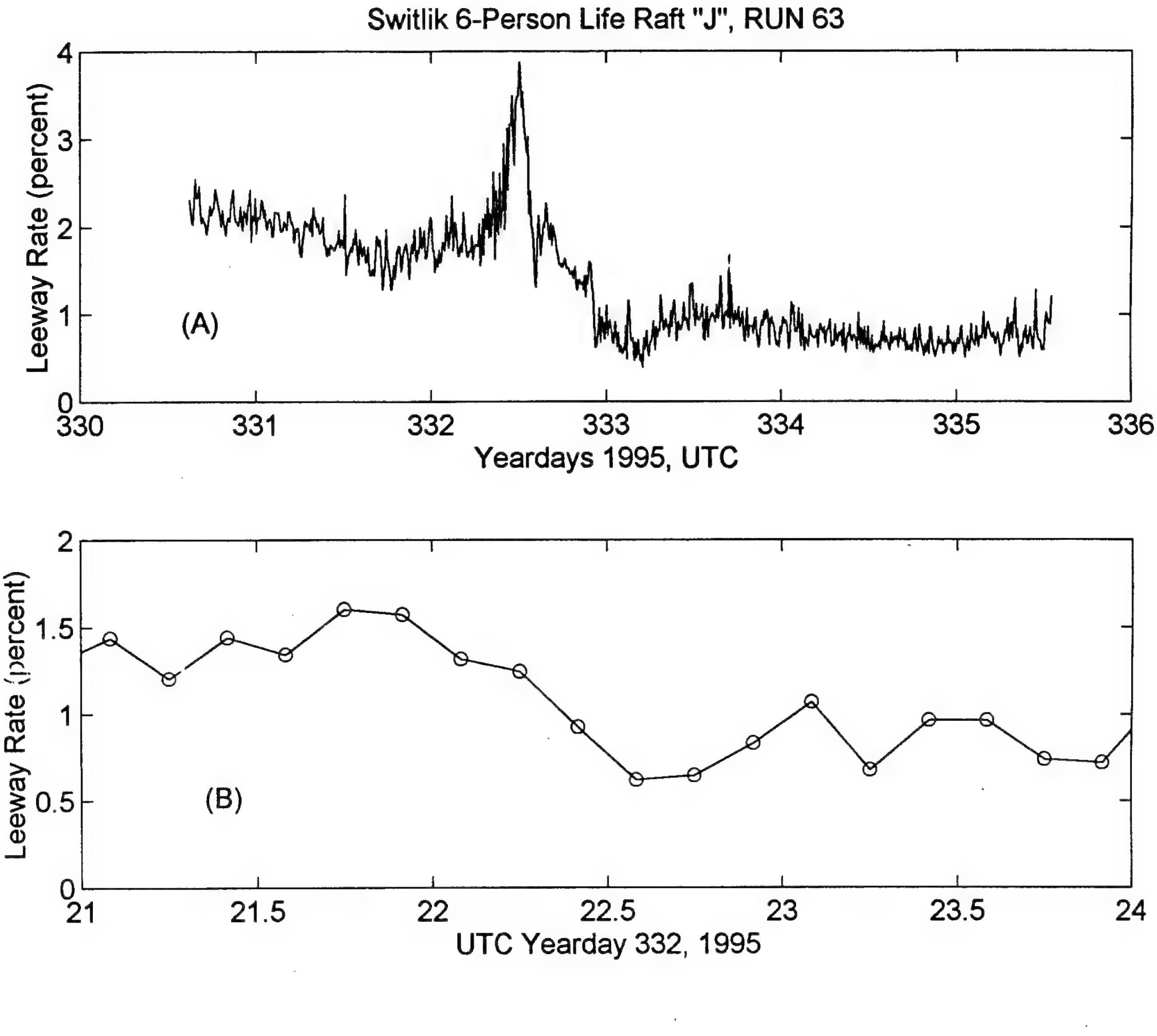


Figure 4-26. Time Series of Leeway Rate for the Switlik 6-Person Life Raft "J", Leeway Run 63. (A) is the complete record, while (B) is the last 3 hours of Yearday 332, 1995.

### 4.3.2 The Leeway of Switlik 6-Person Life Raft "J"

The data used to compute the leeway of Switlik 6-Person life raft "J" - Standard Configuration with Canopy Intact were 333 10-minute samples from the time the MiniMet® buoy was deployed until the raft swamped at 22:25 UTC on yearday 332. The data for leeway of the Switlik 6-Person life raft "J" -Swamped with Canopy Collapsed were 377 10-minute samples from 22:35 UTC, yearday 332, until the raft was recovered at on yearday 335 at 13:30 UTC. The MiniMet® wind direction sensor failed at 331 12:15 UTC, which limits the leeway angle and leeway components data to the first 128 samples of the data record when the life raft was in the standard configuration and its canopy was intact. The wind source used for Leeway Run 63 is the moored MiniMet® buoy which was 13 to 53 kilometers from life raft "J" (see Table 3-3).

#### 4.3.2.1 Leeway Angle, Rate and Speed

Leeway angle of the life raft "J" -Standard Configuration with Canopy Intact was limited to 127 data points collected between 330 14:55 UTC and 331 12:05 UTC, when the wind direction sensor on the MiniMet buoy failed. Leeway angle ranged from -4° to +21°, with a mean of 8.0° and a standard deviation of 5.0 °. The mean of the absolute values of leeway angle was 8.3° with a standard deviation of 4.5°. Leeway angle for life raft "J" is summarized in Table 4-21. Leeway angle versus 10m wind speed is shown in Figure 4 -27.

Table 4-21

Leeway Angle (degrees)
Switlik 6-Person Life Raft "J" -Standard Configuration with Canopy Intact

| Leeway | # | Leeway Angle | | | | Abs. Angle | |
|---|---|---|---|---|---|---|---|
| Run | samples | mean | s.dev. | min | max | mean | s.dev. |
| 63 - Std. Config. | 127 | 8.0 | 5.0 | -4 | 21 | 8.3 | 4.5 |

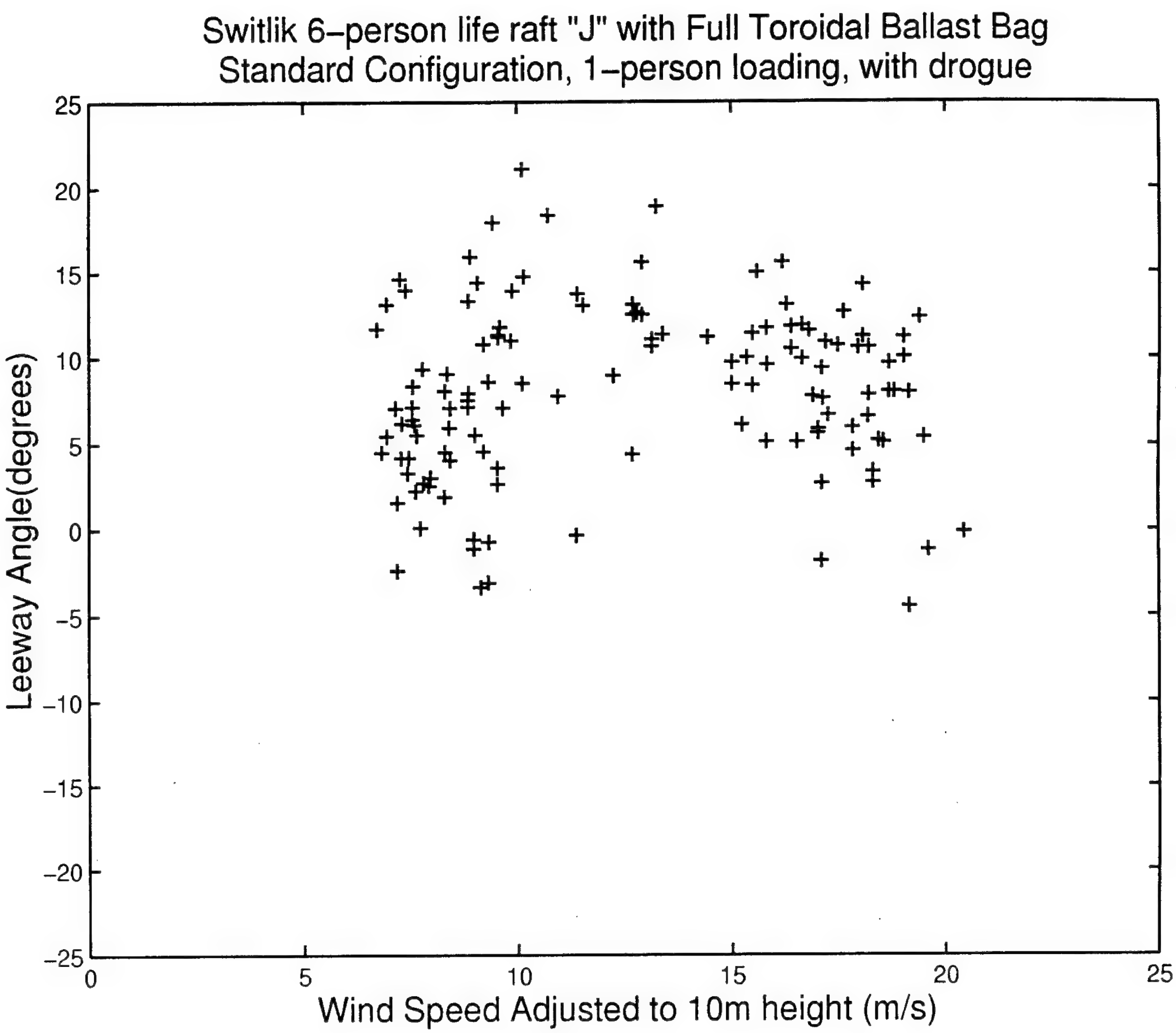


Figure 4-27. Leeway Angle versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact

The leeway rate of life raft "J" - Standard Configuration with Canopy Intact was based upon 333 data points between the start of the combined records of the life raft and the MiniMet® buoy at 330 14:55 UTC and when the life raft swamped at 332 22:15 UTC. The mean leeway rate for this period was 1.95% with an standard deviation of 0.42%, and a range of 1.2% to 3.8%. The leeway rates had a trend that decreased with increasing wind speed in the presence of considerable scatter.

The leeway rate of the Switlik 6-Person life raft "J" - Swamped with Canopy Collapsed was based upon 337 data points from when the life raft swamped at 332 22:15 UTC and when it was recovered on yearday 335 at 13:30 UTC. The mean leeway rate for this period was 0.79% with a standard deviation of 0.17%, and a range of 0.4% to 1.7%.

Table 4.22 summarizes the leeway rate values and Figure 4-28 shows leeway rates versus 10m wind speed for the two life raft "J" configurations.

Table 4-22
Leeway Rate (Percent of $\mathbf{W}_{10m}$)
Switlik 6-Person Life Raft "J"

| Leeway Run | # samples | Leeway Rate mean | s.dev. | min | max |
|---|---|---|---|---|---|
| 63 - Std. Config. | 333 | 1.95 | 0.42 | 1.2 | 3.8 |
| 63 - Swamped | 377 | 0.79 | 0.17 | 0.4 | 1.7 |

The leeway rate dropped 60 percent from 1.95% of $\mathbf{W}_{10m}$ to 0.79% of the $\mathbf{W}_{10m}$ when the life raft's canopy collapsed and the raft filled with water. The mean leeway rate for the swamped life raft "J" was 41% that of the Star·:ard Configura·'on Switlik life raft.

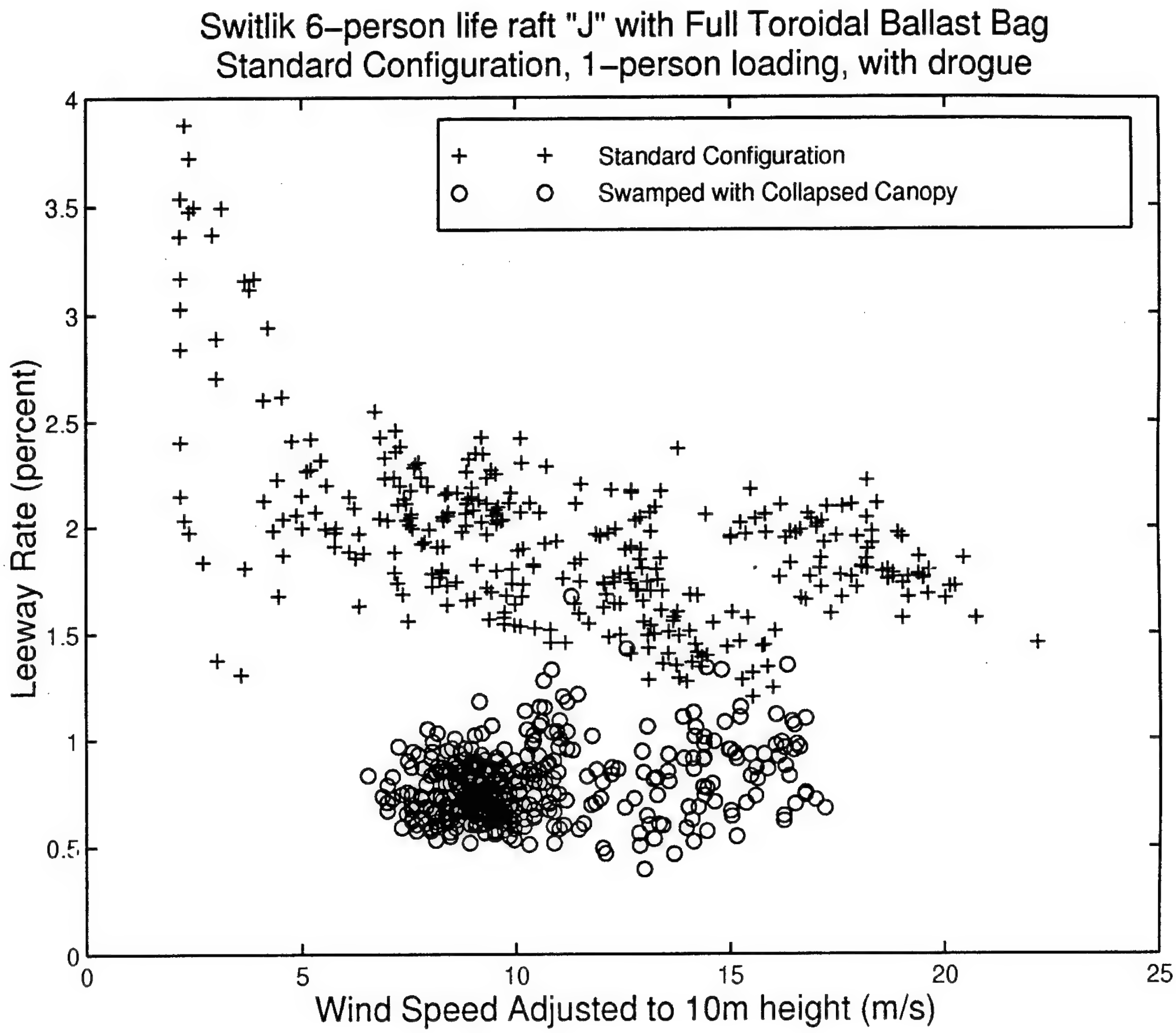


Figure 4-28. Leeway Rate versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact (+) and when the Life Raft was Swamped and Canopy was Collapsed (o).

The leeway speed of the Switlik 6-Person life raft "J" - Standard Configuration with Canopy Intact was based upon 333 data points between the start of the combined records of the life raft and the MiniMet® buoy at 330 14:55 UTC and when the Raft swamped at 332 22:15 UTC. The leeway speed of the Switlik 6-Person life raft "J" - Swamped with Canopy Collapsed was based upon 337 data points from when the life raft swamped at 332 22:15 UTC and when it was recovered on yearday 335 at 13:30 UTC. The leeway speed of the Switlik 6-Person life raft "J" for wind speeds adjusted to 10-meter height is shown in Figures 4-29 and 4-30. The unconstrained and constrained linear regression lines along with the 95% prediction limits of leeway speed on wind speed are also shown. The unconstrained linear regression is summarized in Table 4-23 and the constrained linear regression is summarized in Table 4-24. The 95% prediction limits are summarized in Tables 4-25 and 4-26.

Table 4-23

Unconstrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "J"

| Dependent Variable | Leeway Run 63 | # samples | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| Leeway Speed | Std. Config. | 333 | 2.96 | 1.59 | 0.862 | 3.02 | 2.2 - 22.2 |
| Leeway Speed | Swamped | 377 | -2.17 | 1.01 | 0.629 | 1.99 | 6.5 - 17.2 |

Table 4-24

Constrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "J"

| Dependent Variable | Leeway Run 63 | # samples | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| Leeway Speed | Std. Config. | 333 | 0.0 | 1.815 | 0.842 | 3.23 | 2.2 - 22.2 |
| Leeway Speed | Swamped | 377 | 0.0 | 0.816 | 0.605 | 2.05 | 6.5 - 17.2 |

Table 4-25

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Unconstrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "J"
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Leeway Runs | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| Run 63 - Std. Configuration | 0.0004 | 1.58 | 8..96 | -0.0004 | 1.60 | -3.04 |
| Run 63 - Swamped | 0.0008 | 0.99 | 1.83 | -0.0008 | 1.03 | -6.18 |

Table 4-26

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Constrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "J"
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Leeway Run 63 | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| Run 63 - Std. Configuration | 0.0001 | 1.815 | 6.35 | -0.0001 | 1.815 | -6.35 |
| Run 63 - Swamped | 0.0 | 0.816 | 4.04 | 0.0 | 0.816 | -4.04 |

The differences between the model predictions for the two configuration states of the life raft are readily seen by comparing leeway displacements for the two states and two models, assuming a constant wind speed. Examples are presented in Table 4-27 for steady winds of 10 and 20 meters per second (19. 4 and 28.9 knots) over a 24 hour period.

Table 4-27
Comparison of 24 Hour Leeway Displacements (Kilometers) for
10m Wind Speed of 10m/s and 20m/s
Switlik 6-Person Life Raft "J"
Standard Configuration and Swamped

| Leeway Run 63 | Linear Regression | Displacement after 24 hours for $\mathbf{W}_{10m}$ of 10 m/s (kilometers) | 20 m/s (kilometers) |
|---|---|---|---|
| Standard Configuration | Unconstrained | 16.3 | 30.0 |
| | Constrained | 15.7 | 31.4 |
| Swamped | Unconstrained | 6.9 | 15.6 |
| | Constrained | 7.1 | 14.1 |

For the standard configuration of the life raft, the constrained regression under-estimated by 4 percent the leeway drift of the life raft at moderate winds (10m/s) compared to the unconstrained regression. At high winds (20m/s) the constrained regression over-estimated the leeway drift by 5 percent. When the life raft was swamped, the constrained regression over-estimated by 3 % at moderate winds and under-estimated by 9 % at high wind speeds. However, the constrained regressions were well within the 95% prediction limits of the unconstrained regressions.

When the leeway drift of the swamped configuration was compared to the standard configuration major differences were observed in the displacement. At moderate winds, the leeway displacement of the swamped raft was only 42 percent of that for a fully inflated life raft without any water onboard. At higher wind speeds, the leeway displacement of the swamped life raft was 52 % of that for a similar life raft in the standard configuration.

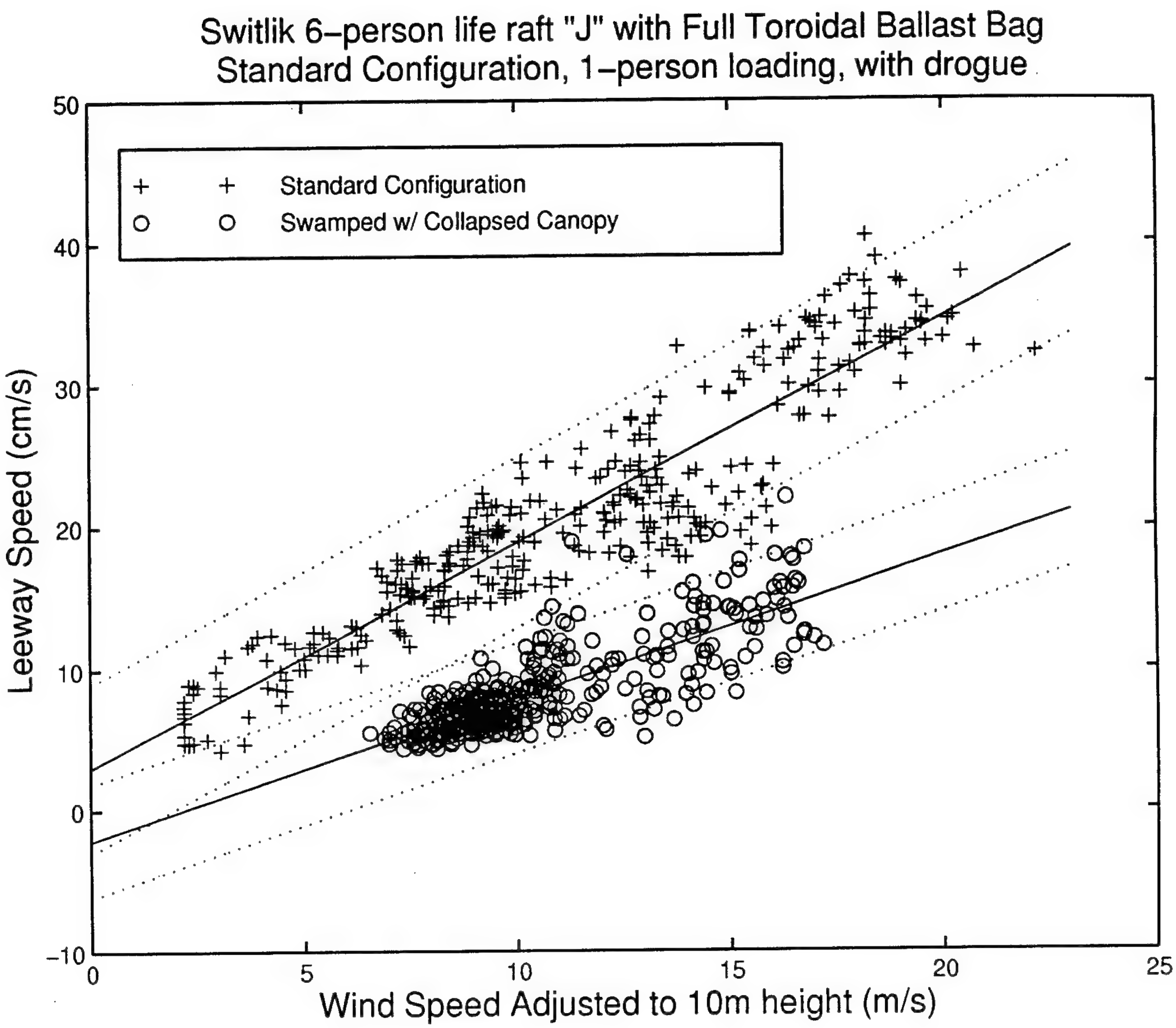


Figure 4-29. The Unconstrained Linear Regressions and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact (+) and when the Life Raft was Swamped and Canopy was Collapsed (o).

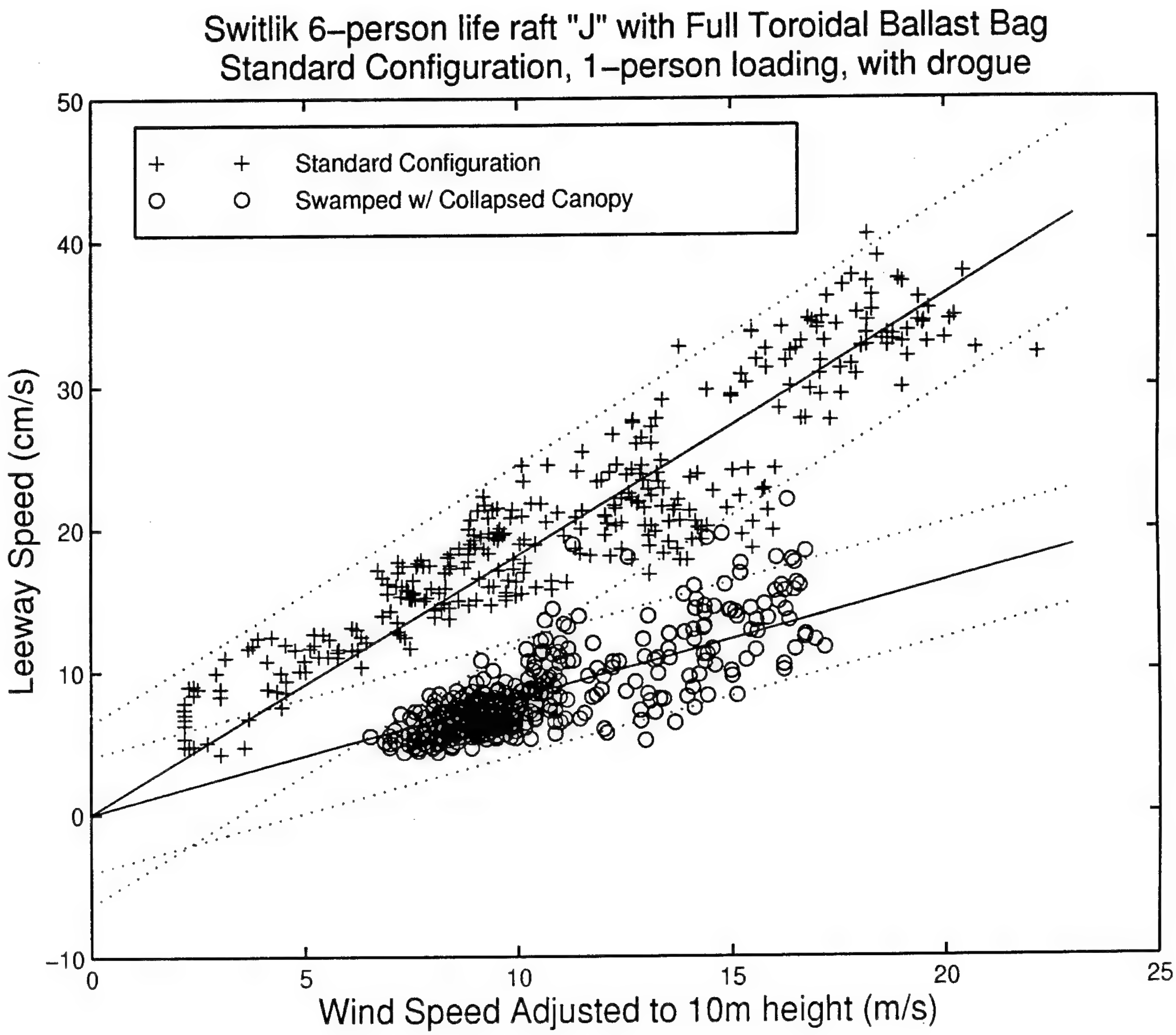


Figure 4-30. The Constrained Linear Regressions and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact (+) and when the Life Raft was Swamped and Canopy was Collapsed (o).

4.3.2.2. Downwind and Crosswind Leeway Components

The downwind (**DWL**) and crosswind (**CWL**) components of leeway for the Switlik 6-Person life raft "J" -Standard Configuration with Canopy Intact are shown in Figures 4-31 through 4-34. The data used to compute the leeway components for this configuration of life raft "J" were limited to 127 data points collected between 330 14:55 UTC and 331 12:05 UTC. The unconstrained (Figures 4-31 and 4-33) and the constrained linear regressions (Figures 4-32 and 4-34) along with the 95% prediction limits are also shown. Tables 4-28 and 4-29 summarize the regressions and Tables 4-30 and 4-31 summarize the 95% prediction limits.

Table 4-28
Unconstrained Linear Regression of Leeway Components (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "J" -Standard Configuration with Canopy Intact

| Dependent Variable | Leeway Run | # samples | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| **DWL** | 63 - Std. Config. | 127 | 4.17 | 1.66 | 0.946 | 1.73 | 6.7 - 20.4 |
| **CWL** | 63 - Std. Config. | 127 | 0.55 | 0.24 | 0.178 | 2.28 | 6.7 - 20.4 |
| Abs(**CWL**) | 63 - Std. Config. | 127 | 0.55 | 0.25 | 0.228 | 2.04 | 6.7 - 20.4 |
| -Abs(**CWL**) | 63 - Std. Config, | 127 | -0.55 | -0.25 | 0.228 | 2.04 | 6.7 - 20.4 |

Table 4-29
Constrained Linear Regression of Leeway Components (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "J" -Standard Configuration with Canopy Intact

| Dependent Variable | Leeway Runs | # samples | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| **DWL** | 63 - Std. Config. | 127 | 0.0 | 1.95 | 0.912 | 2.19 | 6.7 - 20.4 |
| **CWL** | 63 - Std. Config. | 127 | 0.0 | 0.28 | 0.129 | 2.28 | 6.7 - 20.4 |
| Abs(**CWL**) | 63 - Std. Config. | 127 | 0.0 | 0.29 | 0.222 | 2.04 | 6.7 - 20.4 |
| -Abs(**CWL**) | 63 - Std. Config. | 127 | 0.0 | -0.29 | 0.222 | 2.04 | 6.7 - 20.4 |

Table 4-30

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Unconstrained Linear Regression of Leeway Components (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Dependent Variable | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| **DWL** | 0.0007 | 1.64 | 7.72 | -0.0007 | 1.68 | 0.61 |
| **CWL** | 0.0009 | 0.22 | 5.24 | -0.0009 | 0.27 | -4.14 |
| Abs(**CWL**) | 0.0008 | 0.24 | 4.74 | -0.0008 | 0.28 | -3.63 |
| -Abs(**CWL**) | 0.0008 | -0.28 | 3.63 | -0.0008 | -0.24 | -4.74 |

Table 4-31

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Constrained Linear Regression of Leeway Components (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Dependent Variable | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| **DWL** | 0.0001 | 1.95 | 4.33 | -0.0001 | 1.95 | -4.33 |
| **CWL** | 0.0001 | 0.28 | 4.51 | -0.0001 | 0.28 | -4.52 |
| Abs(**CWL**) | 0.0001 | 0.29 | 4.03 | -0.0001 | 0.29 | -4.03 |
| -Abs(**CWL**) | 0.0001 | -0.29 | 4.03 | -0.0001 | -0.29 | -4.03 |

The data set for downwind component of leeway of the of the standard configuration of life raft "J" was limited to just 127 samples, fortunately, those samples were spread over a range of wind speeds (**$W_{10m}$** was 6.7 to 20.4 m/s). The **DWL** was highly correlated with wind speed, ($r^2$ = .944). The constrained regression of **DWL** was 6% lower than the unconstrained regression at 10m/s of wind and 4% high at 20m/s of wind. However, this was well within the 95% prediction limits for constrained regression.

The crosswind component of leeway was also limited to 127 samples spread over the same wind range as the **DWL** samples. During the period when **CWL** values were collected for life raft "J", the MiniMet Buoy was 14 to 26 km from the life raft. Since the wind data was not collected onboard the craft, but at the MiniMet buoy, the quality of **CWL** data set is limited. **CWL** had limited correlation with wind speed ($r^2$ = .135). With this limited data set of **CWL** values, it was necessary to assume symmetry of **CWL** about the downwind direction, (see Table 3-1 in section 3.2.1). Using the positive and negative absolute values of **CWL** produced a data set that contained values that were symmetrical about the wind speed axis. Regressions of the positive and negative absolute values of **CWL** versus 10m wind speed, are shown in Tables 4-28 and 4-29 and Figures 4-35 and 4-36.

Both downwind and crosswind components (positive and negative absolute values) versus wind speed, along with the unconstrained and constrained regressions and their respective 95% prediction limits, are shown in Figure 4-37 and 4-38. These two figures provide a combined view of both leeway components versus wind speed to describe the leeway behavior of life raft “J”.

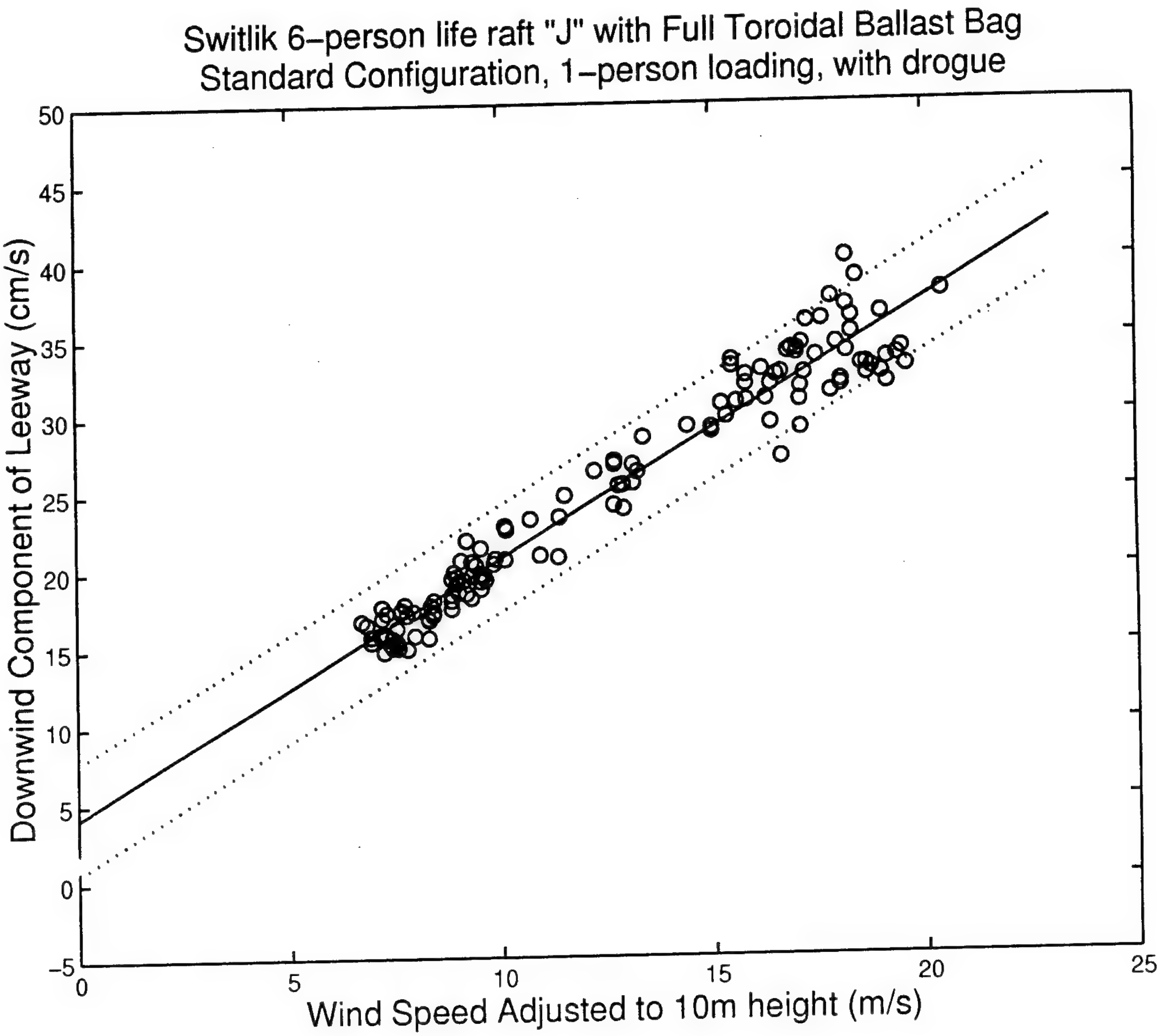


Figure 4-31. The Unconstrained Linear Regression and 95% Prediction Limits of the Downwind Component (o) of Leeway versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact.

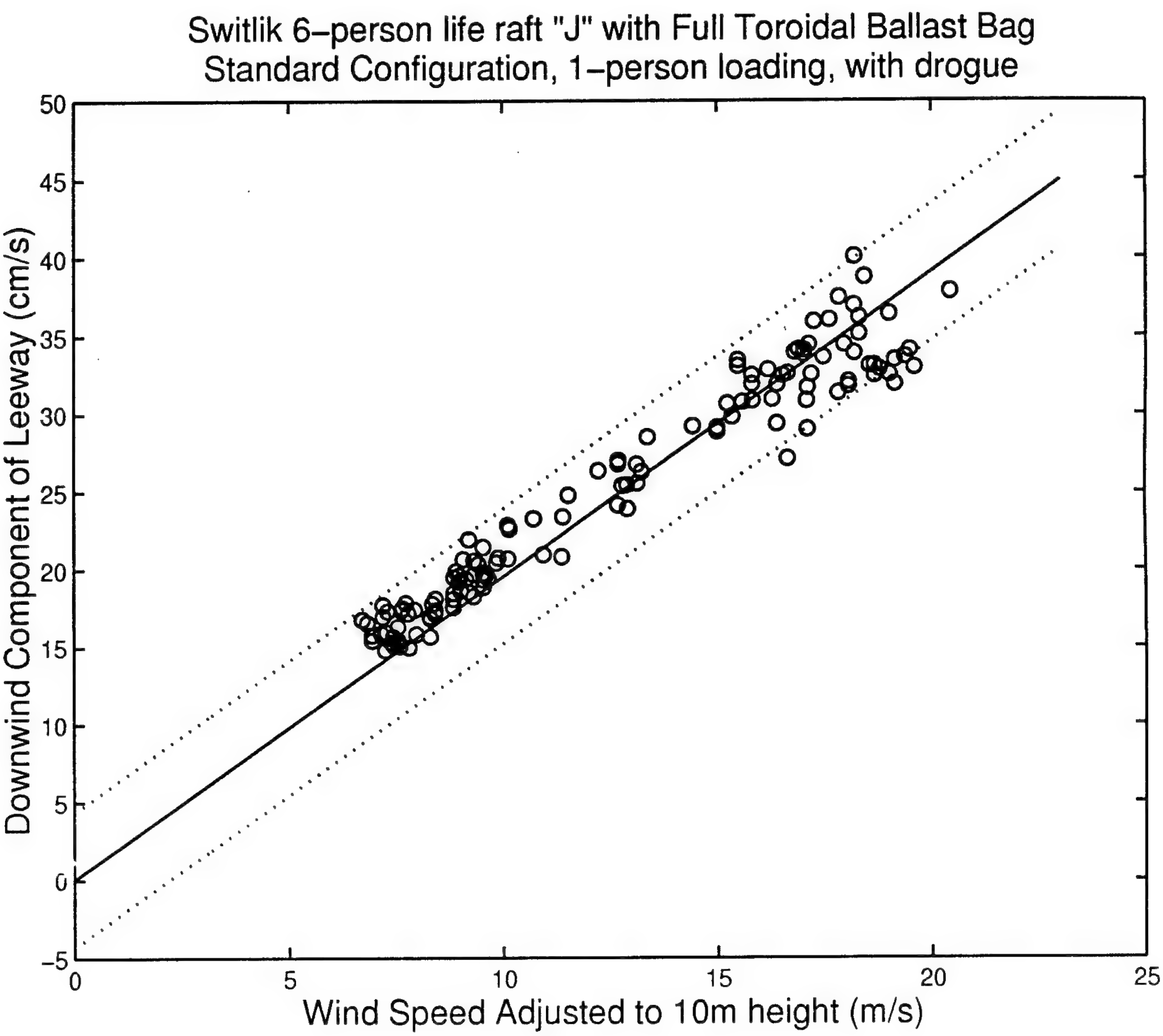


Figure 4-32. The Constrained Linear Regression and 95% Prediction Limits of the Downwind Component (o) of Leeway versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact.

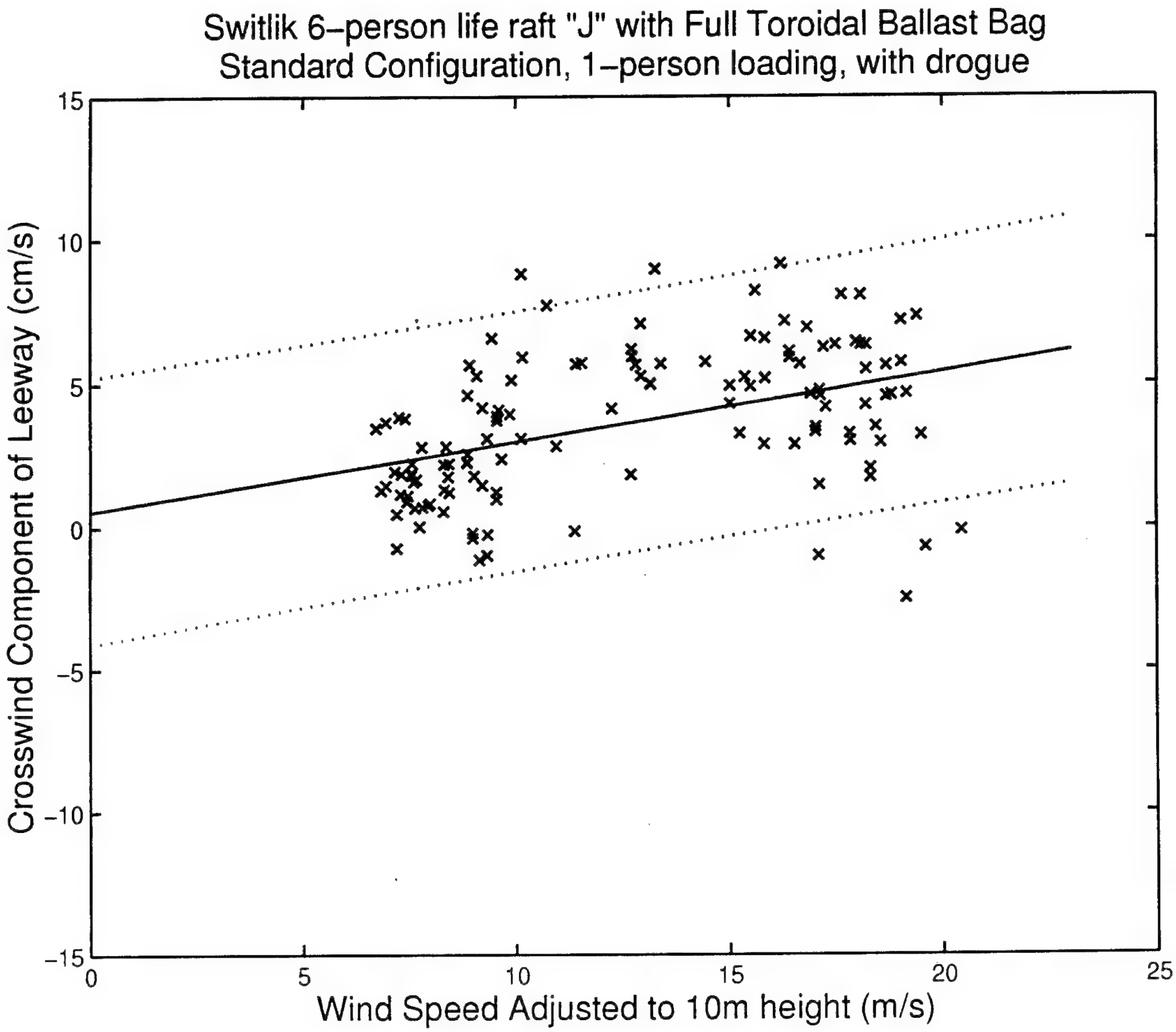


Figure 4-33. The Unconstrained Linear Regression and 95% Prediction Limits of Crosswind Component (+) of Leeway versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact.

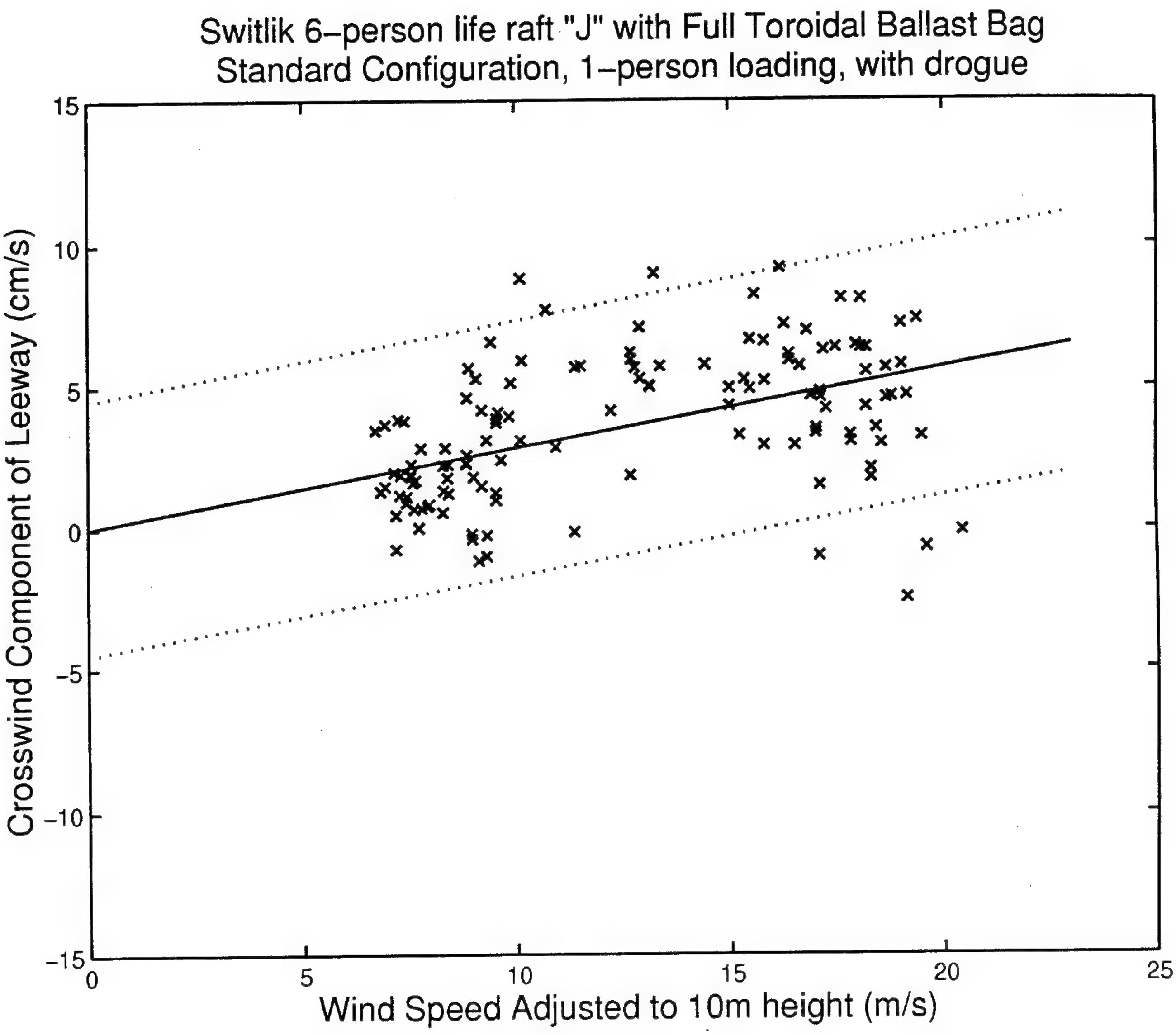


Figure 4-34. The Constrained Linear Regression and 95% Prediction Limits of Crosswind Component (+) of Leeway versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact.

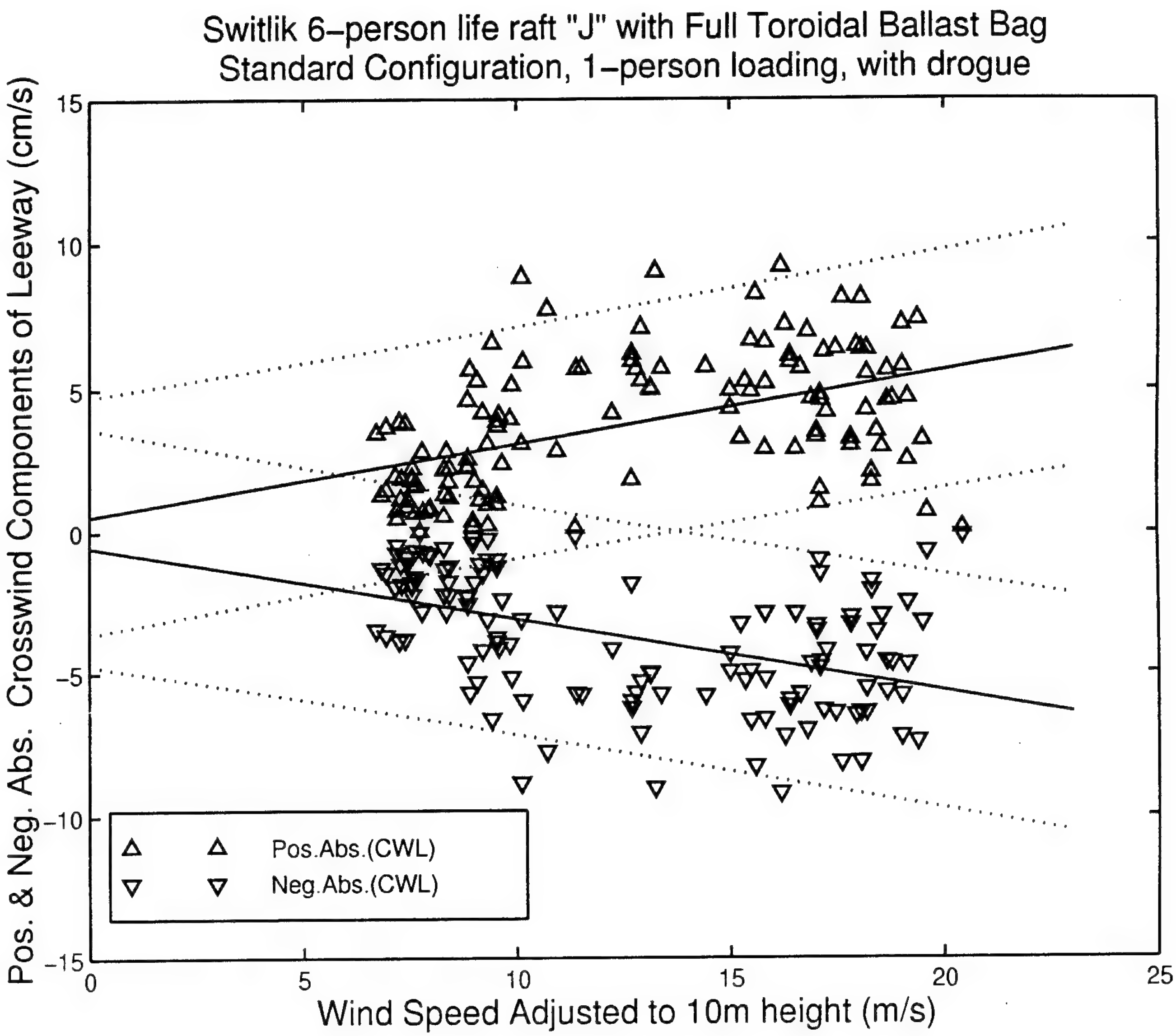


Figure 4-35. The Unconstrained Linear Regressions of the Positive (▲) and Negative (▼) Absolute values of the Crosswind Component of Leeway versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact.

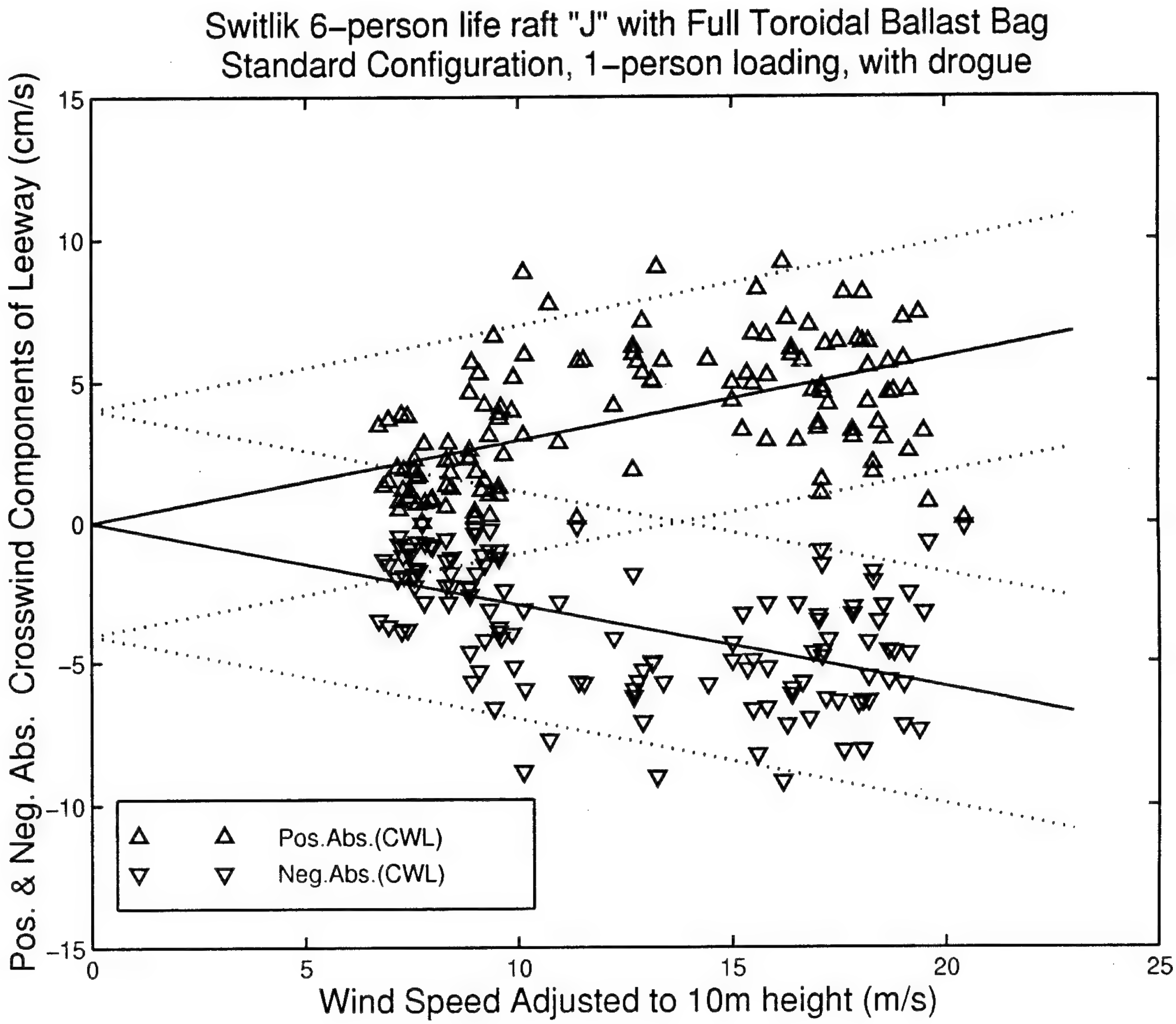


Figure 4-36. The Constrained Linear Regressions of the Positive (▲) and Negative (▼) Absolute values of the Crosswind Component of Leeway versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact.

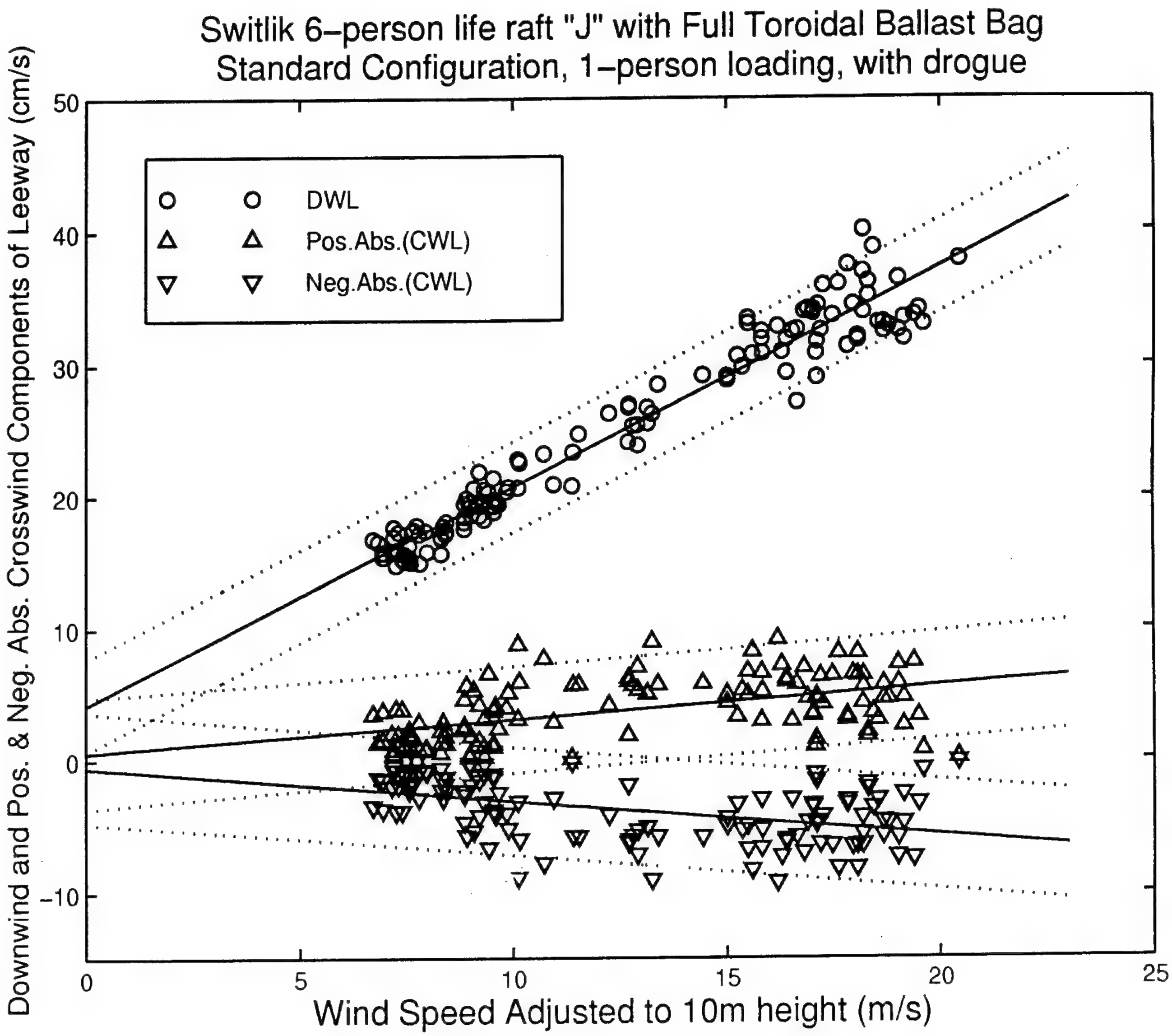


Figure 4-37. The Unconstrained Linear Regressions of the Downwind Component (o) of Leeway, and the Positive (▲) and Negative (▼) Absolute values of the Crosswind Component of Leeway versus Wind Speed at 10m, Switlik 6-Person Life Raft "J" - Standard Configuration with Canopy Intact.

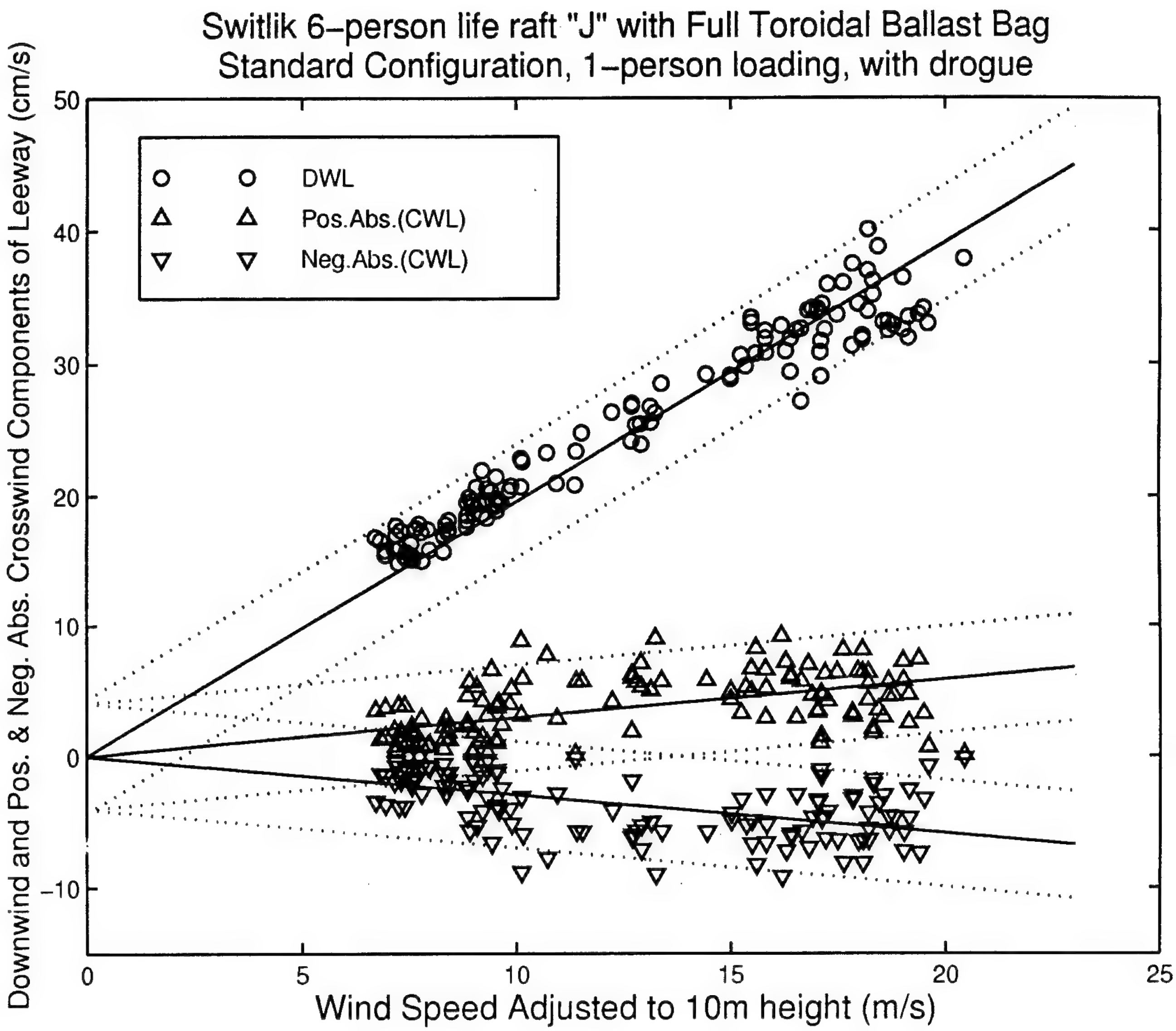


Figure 4-38. The Constrained Linear Regressions of the Downwind Component (o) of Leeway, and the Positive (▲) and Negative (▼) Absolute values of the Crosswind Component of Leeway versus Wind Speed at 10m, Switlik 6-Person Life Raft “J” - Standard Configuration with Canopy Intact.

## 4.4 SWITLIK 6-PERSON LIFE RAFT "H" with FOUR SMALL BALLAST BAGS

Leeway run # 64 was started when Switlik 6-Person life raft "H" was deployed at 19:18 UTC on 30 November (yearday 334) 1995. Data for the life raft "H" consisted of 999 ten-minute averages collected during the 6.9 day drift. The 10 meter wind speed ranged from 2.1 to 22.0 m/s, with significant wave heights of 2.2 to 9.1 meters. The life raft "H" was deployed with a drogue and had loading equivalent to one person.

When the Switlik 6-Person life raft "H" was recovered on 7 December (yearday 341) 1995 at 17:30 UTC, it was missing the wind monitoring system and the GPS receiver/antenna. The raft was upside down. Therefore, the leeway craft changed phase from a standard configuration life raft to a capsized life raft. Upon recovery, the S4® EMCM was attached and streaming upwind of the leeway craft, not in the usual downwind position. The frame that holds the S4® EMCM was bent almost 90 degrees. Apparently, after the S4® EMCM frame was bent, it interfered with the velocity readings from the S4® EMCM. The latter portion of the data record that contained interference had to be discarded. Estimates had to be made as to when the raft capsized and when the leeway record from the S4® EMCM was valid.

The entire leeway drift run 64 occurred after the wind direction sensor failed on the MiniMet® buoy , therefore the analysis of leeway from run 64 is limited to leeway rate and speed. Life Raft "H" was the same life raft previously studied by Fitzgerald (1995) in lightly loaded condition with the drogue deployed. Fitzgerald (1995) collected 182 10-minute samples in wind speeds of 0.9 to 26.2 knots (0.5 to 13.5 m/s) on this configuration of the life raft.

### 4.4.1 The Capsizing of Switlik 6-Person Life Raft "H"

The time series of leeway rate, figure 4-39, clearly shows that the leeway rate fell below 2.0 percent at 18:45 UTC on yearday 336 (time 335.78) and remained below 2.0 percent. After 12:15 UTC on yearday 337, the leeway rate record included unrealistically high values. The data records for life raft "H" were therefore divided into two subsets, before 18:45 UTC, yearday 336 and after that time. The second subset of valid data was limited to the period between 18:55 UTC, yearday 336 and 12:15 UTC, yearday 337. During the first time segment, the life raft was in the standard configuration and during the second segment it was "capsized." Table 4-32 presents the summary of the environmental conditions which prevailed during a two time segments.

Table 4-32
Summary of 1995 Data for the Switlik 6-Person Life Raft "H"

| CRAFT | LEEWAY RUN 64 | DATA (hh:mm) | $W_{10m}$ (m/s) | Wave Height (m) |
|---|---|---|---|---|
| Switlik 6-Person | Total | 65:00 | 4.4 - 18.7 | 3.1 - 7.4 |
| life raft "H" w/4 | Std. Config. | 47:30 | 4.4 - 18.7 | 3.1 - 6.9 |
| small ballast bags | Capsized | 17:30 | 7.7 - 17.4 | 4.0 - 7.4 |

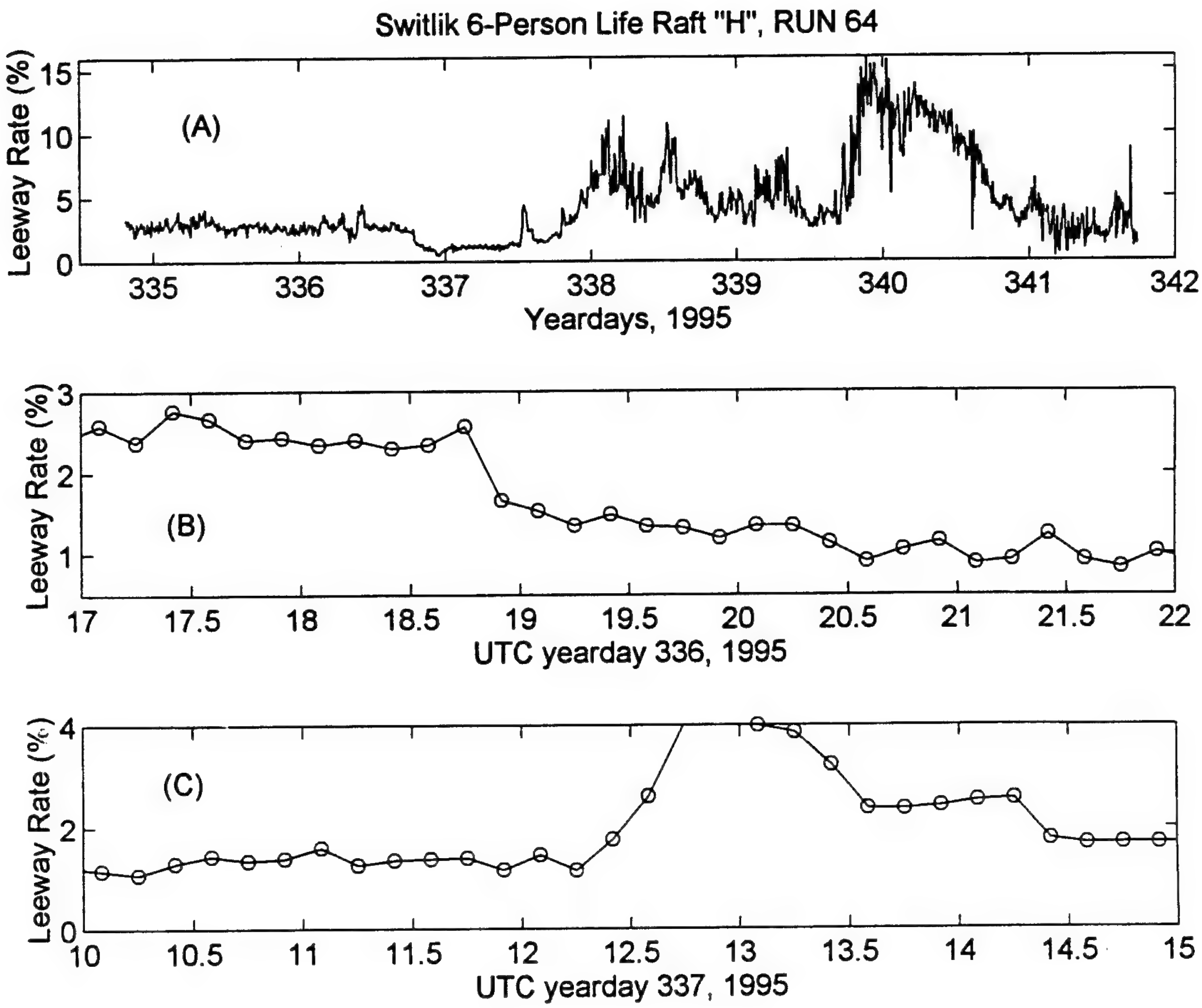


Figure 4-39. Time Series of Leeway Rate for the Switlik 6-Person Life Raft "H", Leeway Run 64. (A) is the complete record, while (B) is 5 hours of Yearday 336, 1995 surrounding the capsizing of the Life Raft and (C) is a 5 hours section of Yearday 337 surrounding the transition from valid to invalid leeway data.

### 4.4.2 The Leeway of Switlik 6-Person Life Raft "H"

The data for the leeway of Switlik 6-Person life raft "H" - Standard Configuration with Canopy Intact were 285 10-minute samples from deployment until the raft capsized at 18:45 UTC on yearday 336. The data for leeway of the Switlik 6-Person life raft "H" - Capsized were 105 10-minutes samples from 18:55 UTC, yearday 336, until 12:15 UTC, yearday 337, when the S4® EMCM was corrupted by the bending of the S4 frame. The wind source used for Leeway Run 64 was the moored MiniMet® buoy which was 3 to 52 kilometers away from life raft "H".

Additional data from 1994 is available on life raft "H" in the standard configuration, l-person loading, with a drogue. Leeway Run # 59 included 182 10-minutes leeway samples. The wind data from Run 59 was from an onboard wind monitoring system, that consisted of an R.M. Young anemometer, KVH compass, and data logging system. The wind data from Run 59 was converted from apparent winds to true winds and then adjusted by Smith (1988) algorithm to the 10-meter level. Methods and preliminary results are presented in Fitzgerald (1995).

#### 4.4.2.1 Leeway Rate and Speed

Table 4-33 summarizes the leeway rate values for the three data subsets involving the Switlik 6-Person life raft "H". Figure 4-37 shows raw leeway rate data for these three subsets. The mean leeway rate for leeway Run 64, the Switlik 6-Person life raft "H" - Standard Configuration with Canopy Intact was 2.82% with a standard deviation of 0.44%, and a range of 1.6% to 4.6%. This was slightly higher than leeway rate for the same life raft with the same configuration from leeway Run 59. The mean leeway rate for Run 59 was 2.22% with a standard deviation of 0.58%. The combined leeway rate mean was 2.59% with a standard deviation of 0.58%.

The mean leeway rate for the Switlik 6-Person life raft "H" - Capsized was 1.13% and a standard deviation of 0.23%, with a range of 0.4% to 1.67%.

Table 4-33

Leeway Rate (Percent of $\mathbf{W}_{10m}$)
Switlik 6-Person Life Raft "H"
1-Person loading, with a drogue

| Leeway Run | # samples | Leeway Rate mean | s.dev. | min | max |
|---|---|---|---|---|---|
| 59 - Std. Config. | 182 | 2.22 | 0.58 | 0.0 | 8.3 |
| 64 - Std. Config. | 285 | 2.82 | 0.44 | 1.6 | 4.6 |
| 59 & 64 Std. Config. | 467 | 2.59 | 0.58 | 0.0 | 8.3 |
| 64 - Capsized | 105 | 1.13 | 0.23 | 0.4 | 1.7 |

The leeway rate dropped 60 percent from 2.82% of the $\mathbf{W}_{10m}$ to 1.13% of the $\mathbf{W}_{10m}$ when the life raft capsized. The mean leeway rate for the capsized life raft "H" was 40% of that for the standard configuration.

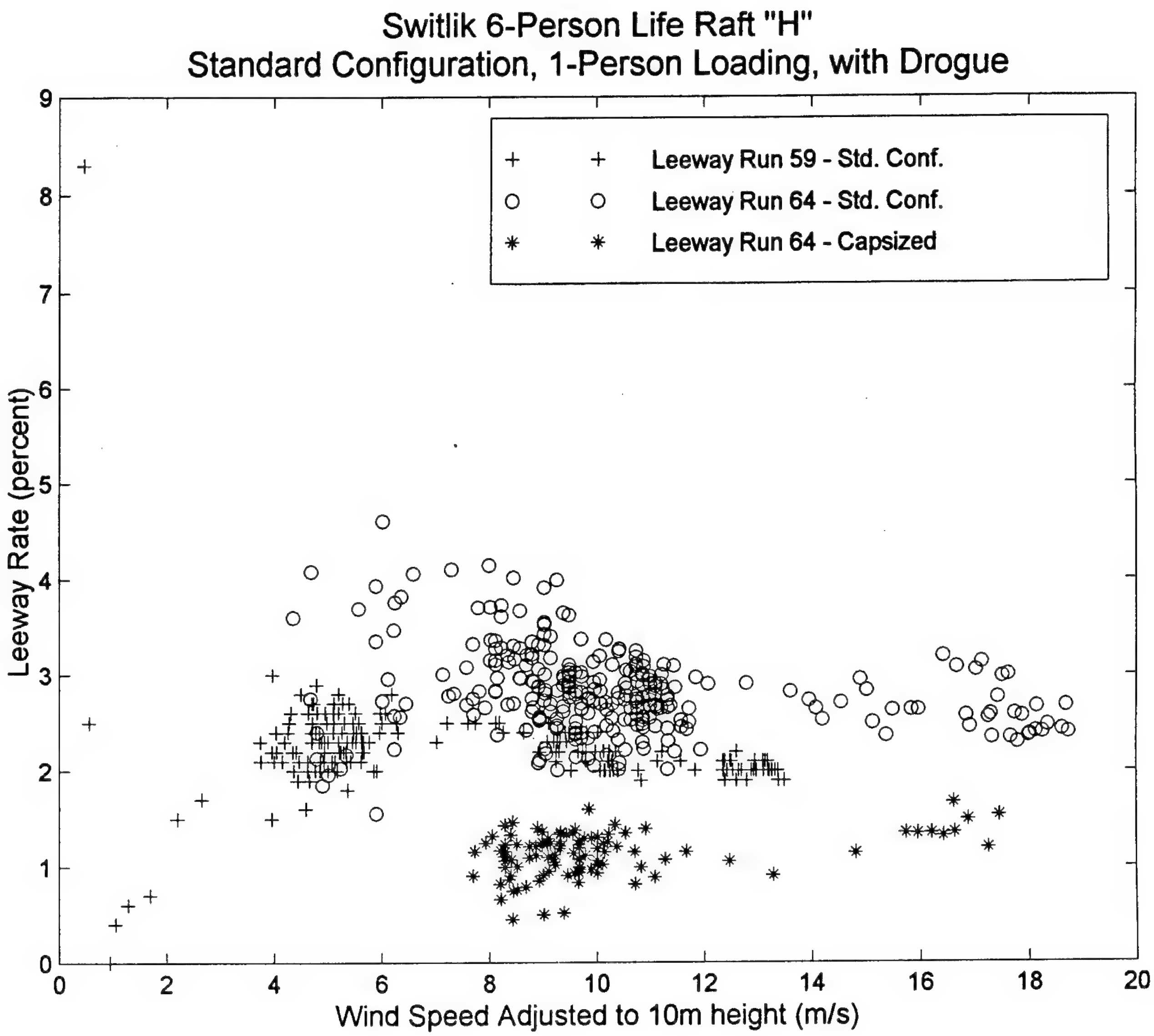


Figure 4-40. Leeway Rate versus Wind Speed at 10m, Switlik 6-Person Life Raft "H" - Standard Configuration with Canopy Intact Run 59 (+) and Run 64 (o) and when the Life Raft was Capsized (*) during Run 64.

The leeway speed of the Switlik 6-Person life raft "H" for wind speeds adjusted to 10-meter height is shown in Figures 4-41 through 4-44. The unconstrained and constrained linear regression lines along with the 95% prediction limits of leeway speed on wind speed are also shown. Unconstrained linear regressions are summarized in Table 4-34 and the constrained linear regressions are summarized in Table 4-35. The 95% prediction limits are summarized in Tables 4-36 and 4-37.

The leeway speeds from Run 59 were below that of Run 64. The standard error ($S_{y/x}$) for Run 59 was considerably smaller than for Run 64. Since Run 59 used winds measured onboard the life raft, and Run 64 used winds from the MiniMet Buoy, which was 3 to 52 km away from the life raft, much of the noise in the Run 64 data set may be attributable to the remote wind data source.

Table 4-34
Unconstrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "H"

| Dependent Variable | Leeway Run | # sample | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| Leeway Speed | 59 Std. Config. | 182 | 1.80 | 1.94 | 0.950 | 1.51 | 0 5 - 13.5 |
| Leeway Speed | 64 Std. Config. | 285 | 4.78 | 2.34 | 0.768 | 3.79 | 4.4 - 18.7 |
| Leeway Speed | 59 & 64 Std. Config. | 467 | 0.68 | 2.53 | 0.808 | 4.24 | 0.5 - 18.7 |
| Leeway Speed | Capsized | 105 | -5.18 | 1.66 | 0.769 | 2.09 | 7.7 - 17.4 |

Table 4-35
Constrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "H"

| Dependent Variable | Leeway Run | # | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| Leeway Speed | 59 Std. Config. | 182 | 0.0 | 2.14 | 0.938 | 1.69 | 0 5 - 13.5 |
| Leeway Speed | 64 Std. Config. | 285 | 0.0 | 2.76 | 0.741 | 4.00 | 4.4 - 18.7 |
| Leeway Speed | 59 & 64 Std. Config. | 467 | 0.0 | 2.59 | 0.808 | 4.25 | 0.5 - 18.7 |
| Leeway Speed | Capsized | 105 | 0.0 | 1.174 | 0.698 | 2.37 | 7.7 - 17.4 |

Table 4-36

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Unconstrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "H"
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Leeway Run | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1$ | $c_2$ | $c_3$ | $c_1^2$ | $c_2$ | $c_3$ |
| Run 59 Std. Config. | 0.0007 | 1.93 | 4.84 | -0.0007 | 1.95 | -1.24 |
| Run 64 Std. Config. | 0.0015 | 2.30 | 12.41 | -0.0015 | 2.36 | -2.85 |
| Runs 59 & 64 Std. Config. | 0.0008 | 2.51 | 9.09 | -0.0008 | 2.54 | -7.73 |
| Run 64 - Capsized | 0.0036 | 1.59 | -0.65 | -0.0036 | 1.74 | -9.71 |

Table 4-37

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Constrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Switlik 6-Person Life Raft "H"
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Leeway Run | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| Run 59 Std. Config. | 0.0001 | 2.14 | 3.33 | -0.0001 | 2.14 | -3.33 |
| Run 64 Std. Config. | 0.0001 | 2.76 | 7.88 | -0.0001 | 2.76 | -7.88 |
| Runs 59 & 64 Std. Config. | 0.0001 | 2.59 | 8.34 | -0.0001 | 2.59 | -8.34 |
| Run 64 - Capsized | 0.0002 | 1.17 | 4.70 | -0.0002 | 1.17 | -4.70 |

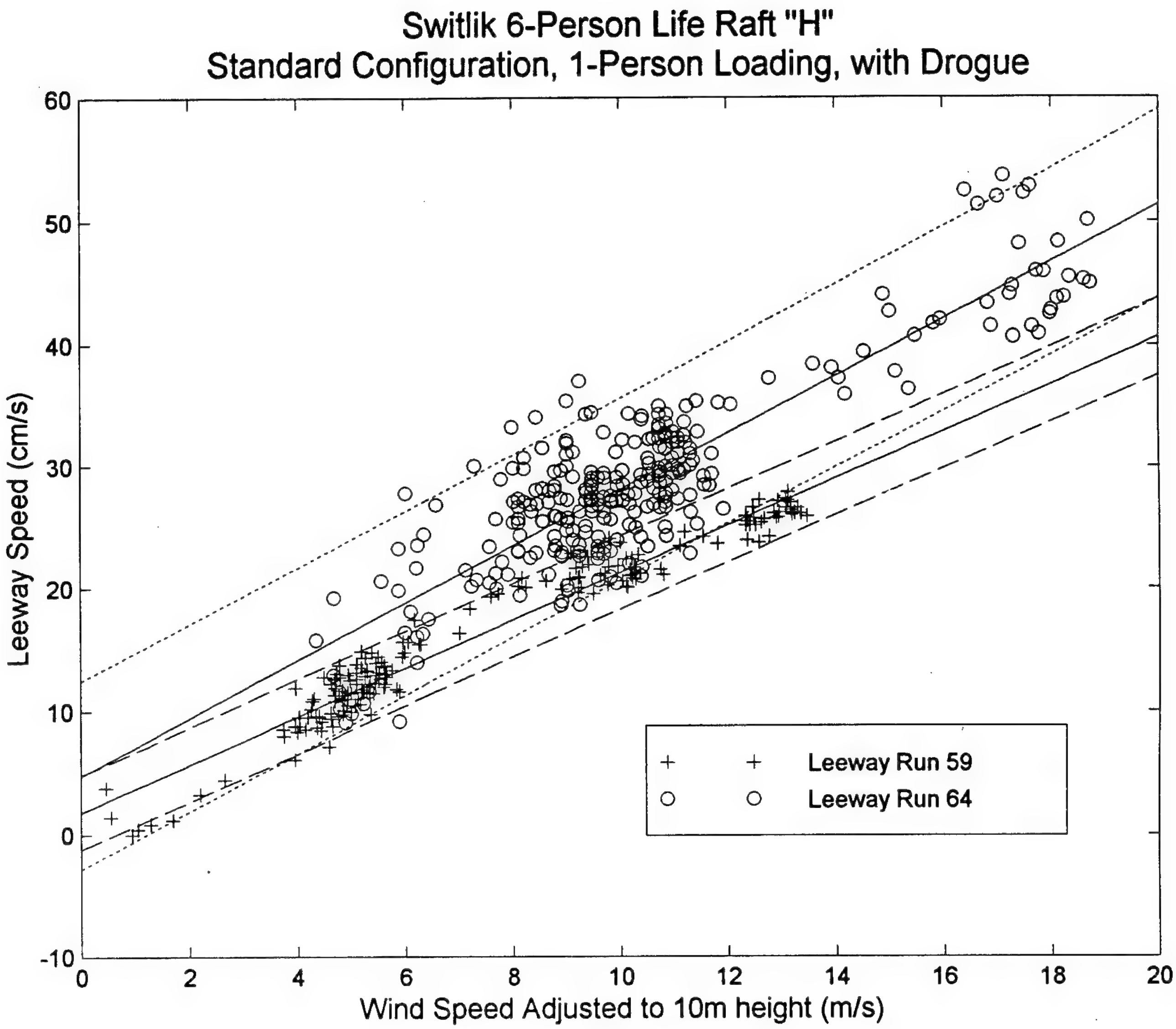


Figure 4-41. The Unconstrained Linear Regression and 95%Prediction Limits of Leeway Speed versus Wind Speed at 10m,Switlik 6-Person Life Raft "H" - Standard Configuration Run 59 (+) and Run 64 (o).

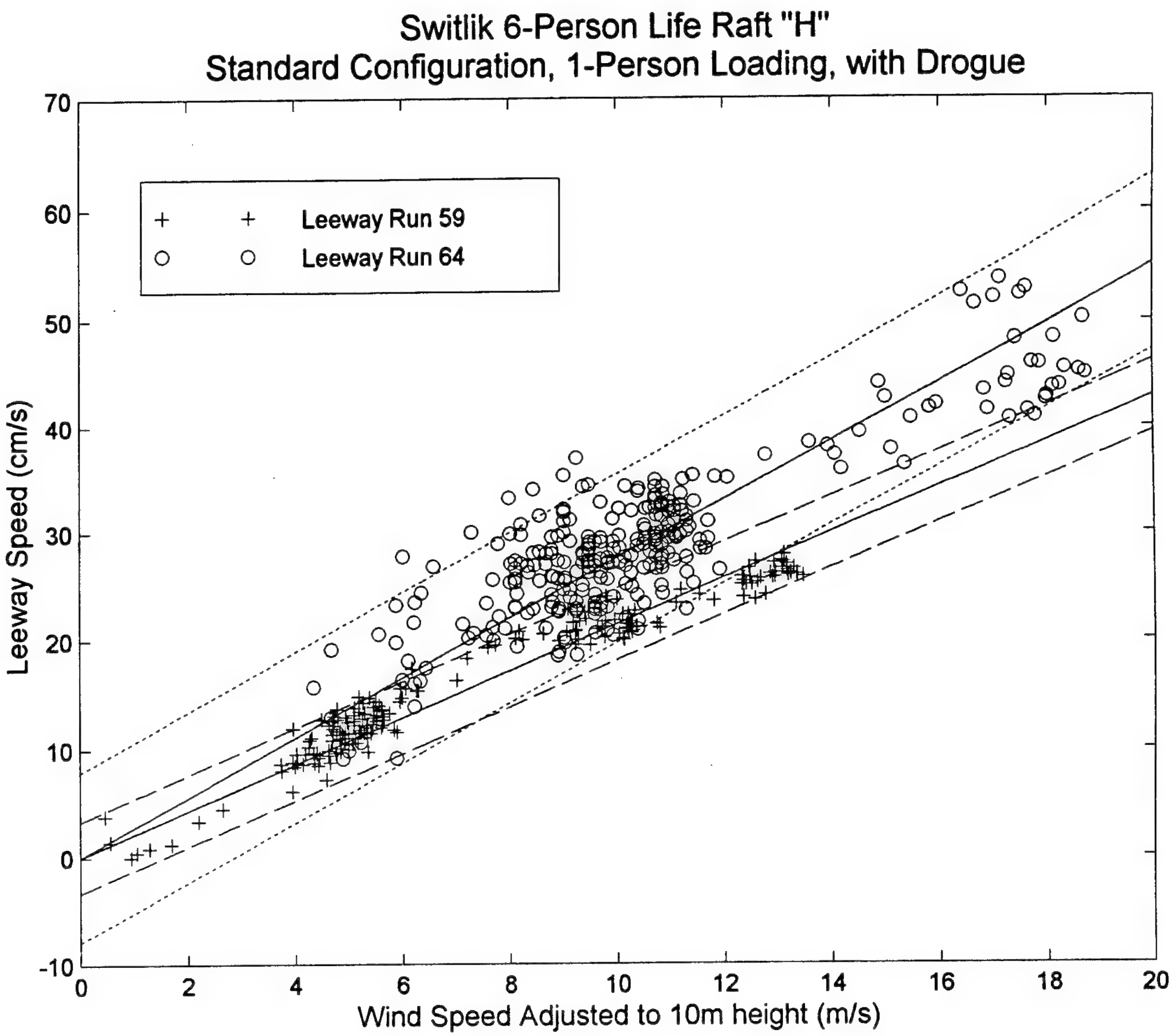


Figure 4-42. The Constrained Linear Regression and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, Switlik 6-Person Life Raft "H" - Standard Configuration, Run 59 (+) and Run 64 (o).

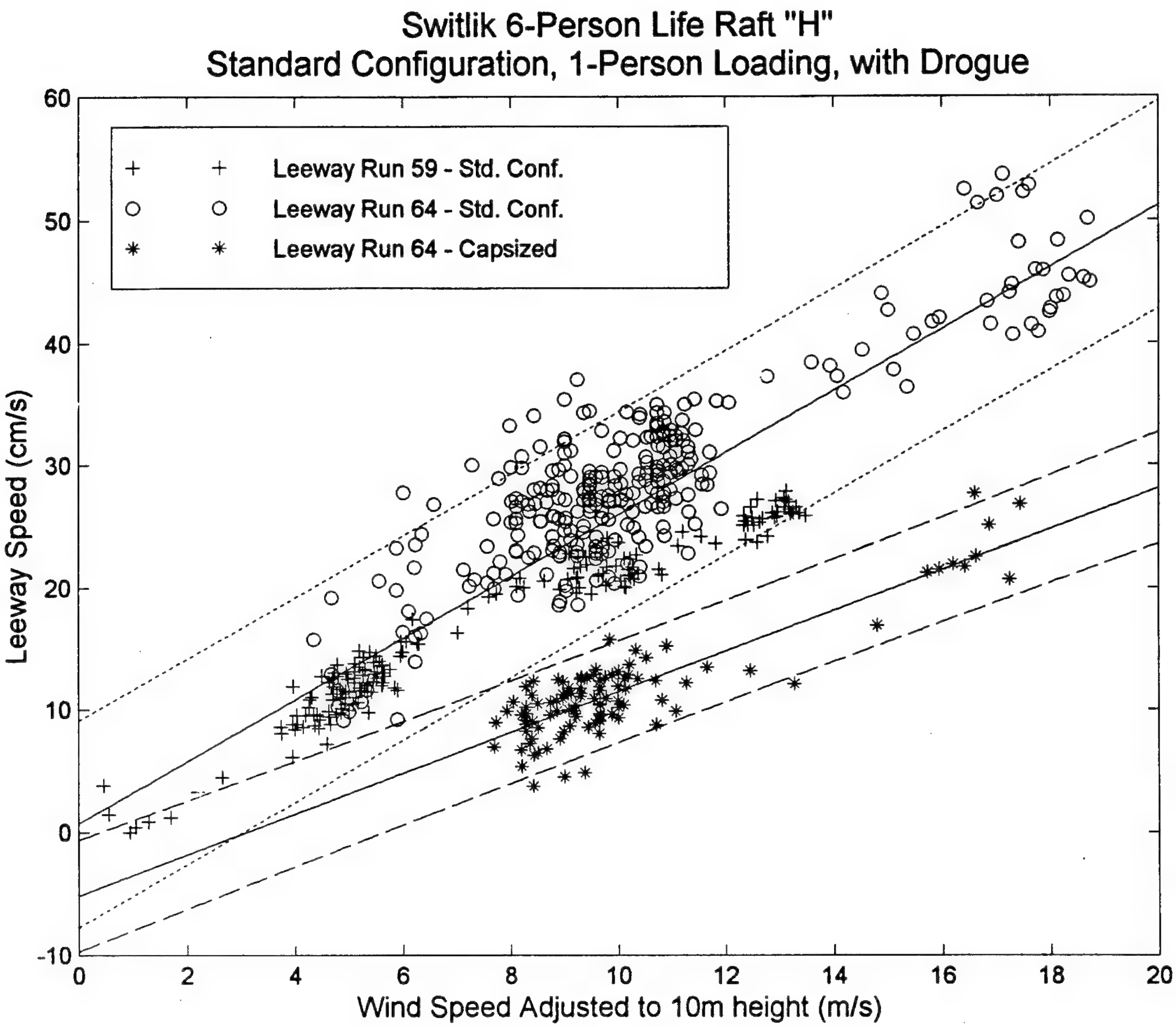


Figure 4-43. The Unconstrained Linear Regression and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, Switlik 6-Person Life Raft "H" - Standard Configuration Run 59 (+) combined with Run 64 (o) and with the Life Raft was capsized (*).

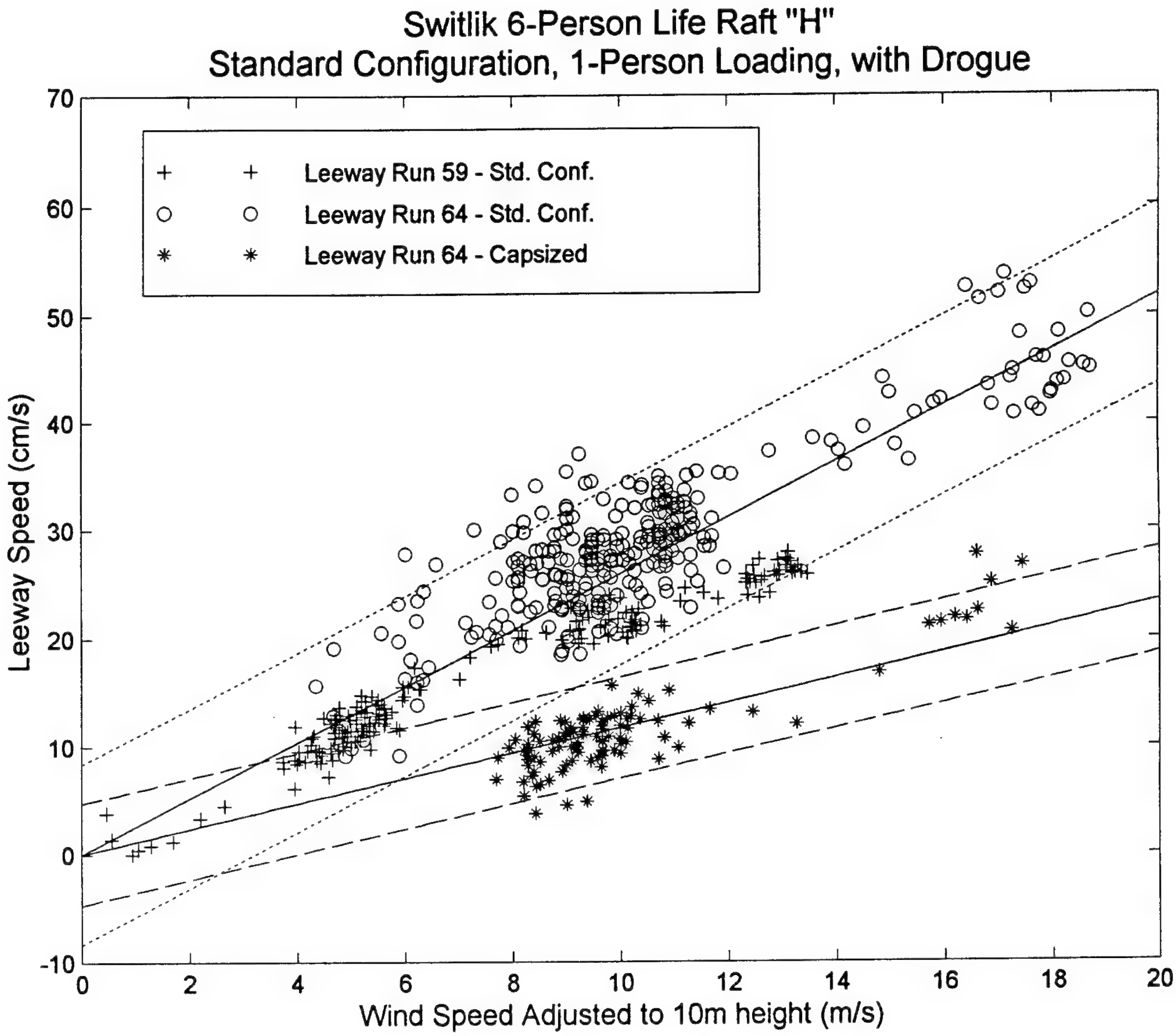


Figure 4-44. The Constrained Linear Regression and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, Switlik 6-Person Life Raft "H" - Standard Configuration, Run 59 (+) combined with Run o4 (o) and when the Life Raft was capsized (*).

The differences between the model predictions for the two configuration states of the life raft are readily seen by comparing leeway displacements for the two states and two models, assuming a constant wind speed. Examples are presented in Table 4-38 for a steady wind of 10 and 20 meters per second (19. 4 and 28.9 knots) over a 24 hour period.

Table 4-38
Comparison of 24 Hour Leeway Displacements (Kilometers) for
10m Wind Speed of 10m/s and 20m/s
Switlik 6-Person Life Raft "J"
Standard Configuration and Capsized

| Leeway Run | Linear Regression | Displacement after 24 hours for $\mathbf{W}_{10m}$ of 10 m/s (kilometers) | 20 m/s (kilometers) |
|---|---|---|---|
| Run 59 Std. Config. | Unconstrained | 18.3 | 35.1 |
| | Constrained | 18.5 | 37.0 |
| Run 64 Std. Config. | Unconstrained | 24.3 | 44.6 |
| | Constrained | 23.8 | 47.7 |
| Runs 59 and 64 Std. Config. | Unconstrained | 22.4 | 44.3 |
| | Constrained | 22.4 | 44.8 |
| Run 64 Capsized | Unconstrained | 9.9 | 24.2 |
| | Constrained | 10.1 | 20.3 |

The difference between Run 59 and Run 64 is readily apparent. At moderate winds (10 m/s) and high winds (20 m/s) Run 59 leeway displacement was 22 to 25% lower than for Run 64. The difference between the two runs is in the source of the wind data used; all other factors (raft and its configuration, loading, drogue, instrumentation) were identical. The source of the wind data for Run 59 was an onboard R.M. Young anemometer mounted at 1.5 meter height. The source of wind data for Run 64 was a R.M. Young anemometer mounted at 3.0 meter height on the MiniMet Buoy located 3 to 52 km away from the raft. Both anemometers were sampled for 10-minute averages and adjusted to the 10-meter reference level using the same procedure (Smith (1988)). Before adjusting the apparent wind speed from Run 59, GPS positions were used to correct the winds from apparent to true wind speed and direction for Run 59, then the adjustment to 10-meter height was made. The only tentative conclusion is that either winds sampled onboard the life raft were reading low, or that the winds from the MiniMet were reading high. Comparisons of winds from onboard life rafts with the MiniMet during the 1993 experiment did not reveal any appreciable differences between the two wind sources. Figure 2-1, which shows AES analysis winds and winds from the MiniMet do not suggest that the wind speeds from the MiniMet were overestimated. Both data set were combined in the analysis. If additional leeway data is collected on this configuration of the life raft, perhaps at that time this difference can be resolved.

When the leeway drift of the capsized configuration was compared to the standard configuration major differences were observed in the displacement. At moderate winds, the capsized raft would drift due to the wind only 45 percent as far as a fully inflated life raft without any water onboard. At higher wind speeds, leeway displacement of a swamped life raft would be 55 % that of a similar life raft in the standard configuration. Clearly, when a life raft capsizes, there is a considerable reduction in its leeway speed.

Life raft "H" was configured with an inflated canopy and four small ballast bags, while life raft "J" had an inflated canopy and a deep toroidal ballast bag. When the displacements are calculated using the unconstrained regressions and 24 hours of moderate winds, life raft "J" would drift 73 percent of the distance life raft "H" would drift, and 68 percent as far at high wind speeds. This demonstrates the effectiveness of large ballast bags in slowing down the leeway drift of a life raft.

## 4.5 DUNLOP-BEAUFORT 5-SIDED, 4-PERSON LIFE RAFT

Leeway run # 22 was started when the Beaufort Five-Sided, 4-Person life raft was deployed at 21:43 UTC (18:13 NST) on 3 December (yearday 338) 1992. Data for this life raft consisted of 523 ten-minute averages collected during the first 3.6 days of the 4.8 day drift. The 10 meter wind speed ranged from 0.3 to 19.5 m/s, with significant wave heights of 1.4 to 6.9 meters. The Beaufort Five-Sided, 4-Person life raft was deployed with a drogue and a loading equivalent to 4 persons.

When the life raft was recovered on 8 December (yearday 343) 1992 at 16:40 UTC (13:10 NST), it was capsized. Therefore, the leeway craft changed phase from a standard configuration life raft to a capsized life raft. Before the record could be divided into two parts, an estimate had to be made as to when the raft capsized.

Previous studies of this life raft include ten other leeway runs with four configurations: 1-person and 4-persons loading; drogued and undrogued. See Fitzgerald et al. (1993) and (1994) for analysis of the standard configurations of this life raft.

### 4.5.1 The Capsizing of Beaufort Five-Sided, 4-Person Life Raft

The time series of leeway rate, figure 4-45, clearly shows that the leeway rate fell below 2.0 percent after 06:55 UTC on 6 December (yearday 341) 1992, (time 341.29) and remained well below 2.0 percent thereafter. The data records for this life raft were therefore divided into two subsets, before 06:55 UTC, yearday 341,1992 and after that time. During the first time segment, the life raft was "standard configuration" and during the second time segment it was "capsized." Table 4-39 presents the summary of the environmental conditions which prevailed during the two time segments.

Table 4-39
Summary of Data for the Beaufort Five-Sided, 4-Person Life Raft
4-person loading, with drogue

| CRAFT | LEEWAY RUN 22 | DATA (hh:mm) | $W_{10m}$ (m/s) | Wave Height (m) |
|---|---|---|---|---|
| Beaufort 5-sided 4-Person Life Raft | Total | 87:10 | 0.3 - 19.5 | 1.5 - 4.6 |
| | Std. Config. | 81:10 | 0.3 - 19.5 | 1.5 - 4.6 |
| | Capsized | 6:00 | 16.2 - 18.8 | 4.3 - 4.6 |

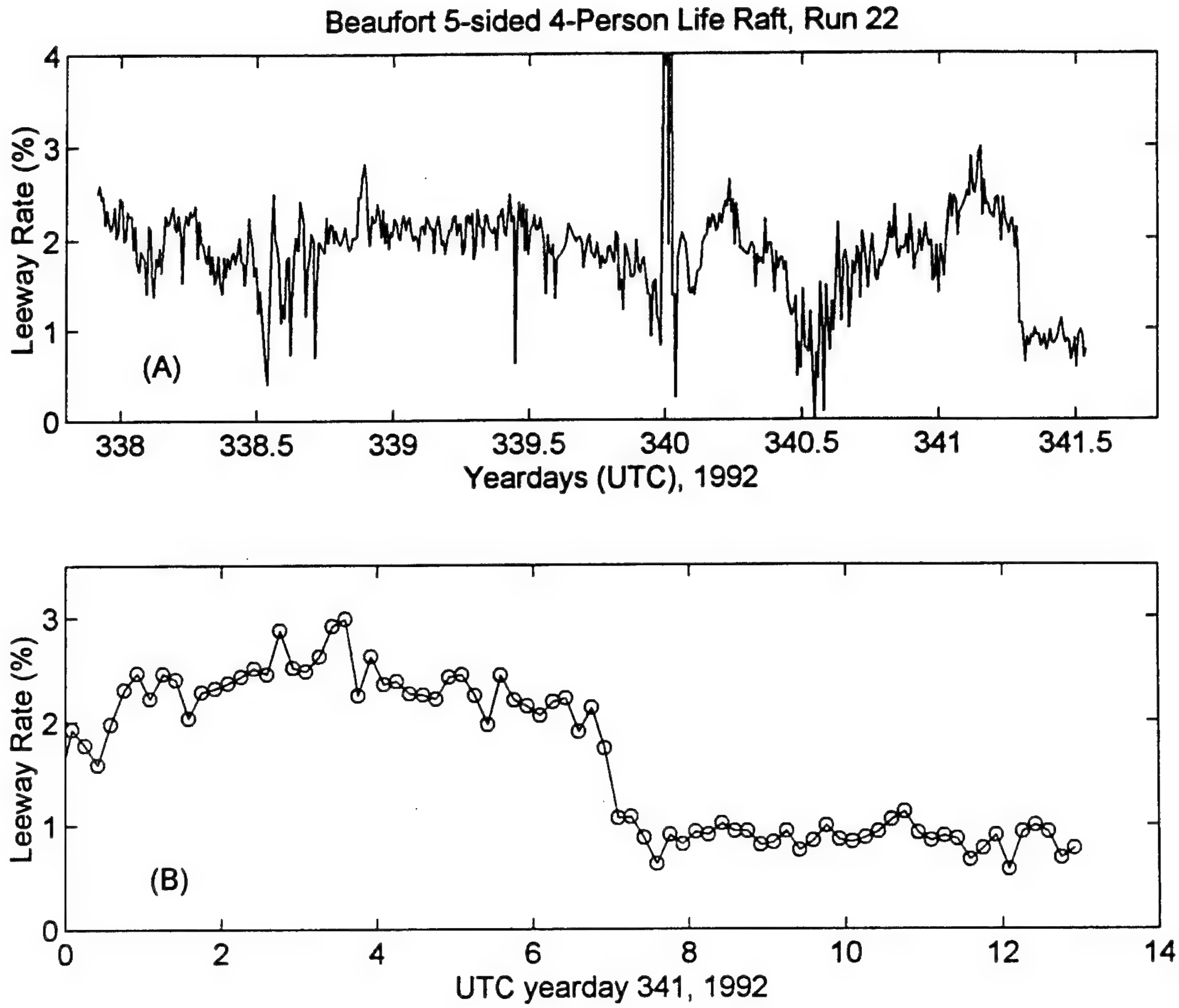


Figure 4-45. Time Series of Leeway Rate for the Beaufort Five-Sided, 4-Person Life Raft Leeway Run 63. (A) is the complete record, while (B) is the first 14 hours of Yearday 341, 1992, which includes the transition from standard configuration to capsized configuration.

#### 4.5.2 The Leeway of Beaufort Five-Sided, 4-Person Life Raft

The data used to compute the leeway for Run # 22, Beaufort Five-Sided, 4-Person life raft - Standard Configuration with Canopy Intact were 487 10-minute samples from deployment until the raft capsized at 06:55 UTC on yearday 341, 1992. The data for leeway of the Beaufort Five-Sided, 4-Person life raft - Capsized were 36 10-minute samples from 07:05 UTC, yearday 341, until 13:05 UTC, yearday 342, when the Leeway Run 23 ended. The wind source used for the capsized portion of Leeway Run 22 was from Leeway Run 23, a drifting Tulmar 4-person life raft. Analysis here was limited to leeway rate and speed.

##### 4.5.2.1 Leeway Rate and Speed

The mean leeway rate for the Beaufort Five-Sided, 4-Person life raft - Standard Configuration was 1.93% with a standard deviation of 0.58%, and a range of 0.0% to 8.9%. Four values of leeway rate exceeded 4% at yearday 340.0, these points were associated with very low wind speeds, as shown in Figure 4-46.

The mean leeway rate for the Beaufort Five-Sided, 4-Person life raft - Capsized was 0.89% with a standard deviation of 0.12%, and a range of 0.58% to 1.13%. Table 4-40 summarizes the leeway rate values for both configurations the Beaufort Five-Sided, 4-Person life raft and Figure 4-46 shows leeway rate these configurations.

Table 4-40
Leeway Rate (Percent of $\mathbf{W_{10m}}$)
Beaufort Five-Sided, 4-Person Life Raft
4-person loading, with drogue

| Leeway Run | # samples | Leeway Rate mean | s.dev. | min | max |
|---|---|---|---|---|---|
| 22 - Std. Config. | 487 | 1.93 | 0.58 | 0.0 | 8.9 |
| 22 - Capsized | 36 | 0.89 | 0.12 | 0.6 | 1.1 |

The leeway rate dropped 54 percent from 1.93% of the $\mathbf{W_{10m}}$ to 0.89% of the $\mathbf{W_{10m}}$ when the life raft capsized. The mean leeway rate of the capsized Beaufort life raft was 46% that of the standard configuration.

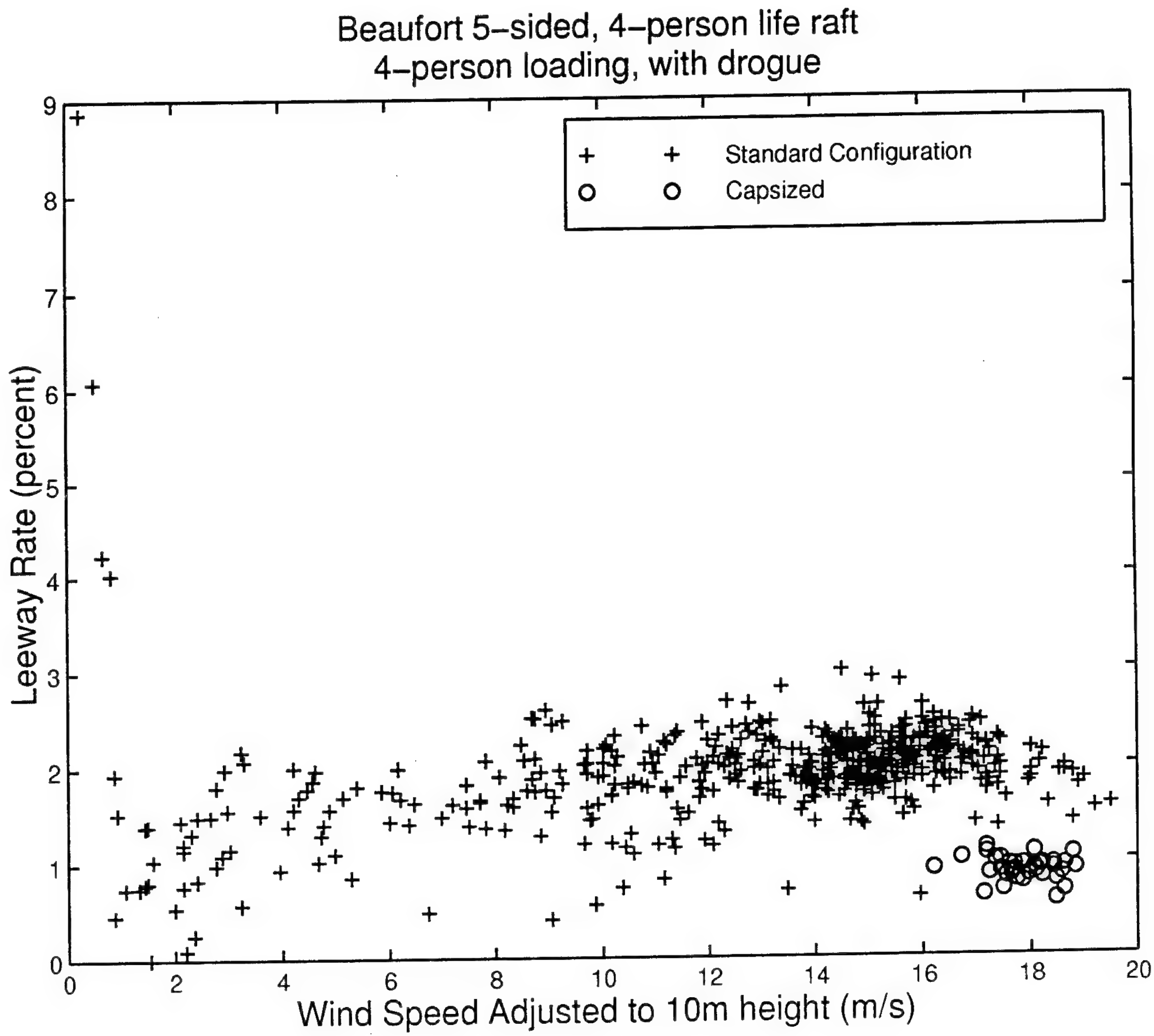


Figure 4-46. Leeway Rate versus Wind Speed at 10m, Beaufort Five-Sided, 4-Person Life Raft - Standard Configuration (+) and when the Life Raft was Capsized (o).

The leeway speeds of the Beaufort Five-Sided, 4-Person life raft for wind speeds adjusted to 10-meter height is shown in Figures 4-47 and 4-48. The unconstrained and constrained linear regression lines along with the 95% prediction limits of leeway speed on wind speed are also shown. Unconstrained linear regression is summarized in Table 4-41 and the constrained linear regression is summarized in Table 4-42. The 95% prediction limits are summarized in Tables 4-43 and 4-44.

Table 4-41

Unconstrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Beaufort Five-Sided, 4-Person Life

| Dependent Variable | Leeway Run 22 | # | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| Leeway Speed | Std. Conf | 487 | -2.92 | 2.21 | 0.836 | 4.24 | 0.3 - 19.5 |
| Leeway Speed | Capsized | 36 | 10.99 | 0.27 | 0.005 | 2.19 | 16.2 - 18.8 |

Table 4-42

Constrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Beaufort Five-Sided, 4-Person Life

| Dependent Variable | Leeway Run 22 | # | a | b | $r^2$ | $S_{y/x}$ | $W_{10m}$ (m/s) |
|---|---|---|---|---|---|---|---|
| Leeway Speed | Std. Conf | 487 | 0.0 | 1.998 | 0.828 | 4.34 | 0.3 - 19.5 |
| Leeway Speed | Capsized | 36 | 0.0 | 0.885 | -0.023 | 2.19 | 16.2 - 18.8 |

Table 4-43

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Unconstrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Beaufort Five-Sided, 4-Person Life
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Leeway Run 22 | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$) | $c_3$ |
| Run 22 - Std. Conf | 0.0005 | 2.19 | 5.49 | -0.0005 | 2.22 | -11.32 |
| Run 22 - Capsized | 0.0302 | -1.35 | 34.9 | -0.0302 | 1.89 | -12.93 |

Table 4-44

The Coefficients of the Polynomials Describing
95% Prediction Limits of the
Constrained Linear Regression of Leeway Speed (cm/s)
on 10m Wind Speed (m/s)
Beaufort Five-Sided, 4-Person Life
($c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3)

| Leeway Run 22 | Upper limits | | | Lower Limits | | |
|---|---|---|---|---|---|---|
| | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| Run 22 - Std. Conf | 0.0 | 2.00 | 8.52 | 0.0 | 2.00 | -8.52 |
| Run 22 - Capsized | 0.0002 | 0.88 | 4.45 | -0.0002 | 0.88 | -4.44 |

With just 36 data points available for the capsized configuration of this raft, all of which are clustered between 16 and 19 m/s of wind, both unconstrained and constrained regressions were not significant ($r^2$ values near zero). Until further data is collected on this life raft in the capsized configuration, only the constrained regression can be tentatively considered to be useful. The unconstrained regression for the capsized configuration should not be used.

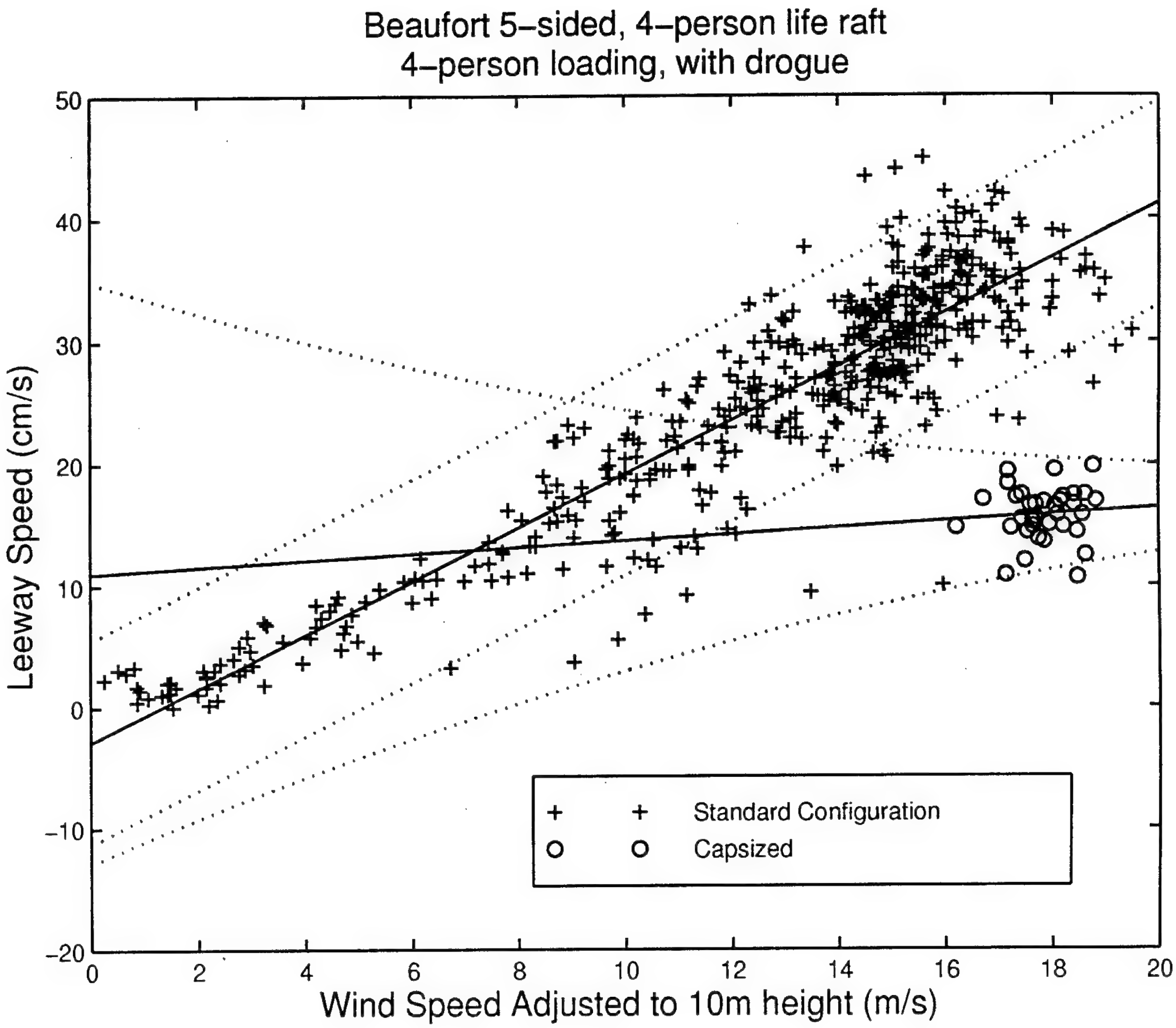


Figure 4-47. The Unconstrained Linear Regression and 95% Prediction Limits of Leeway Speed versus Wind Speed at 10m, Beaufort Five-Sided, 4-Person Life - Standard Configuration (+) and when the Life Raft was Capsized (o).

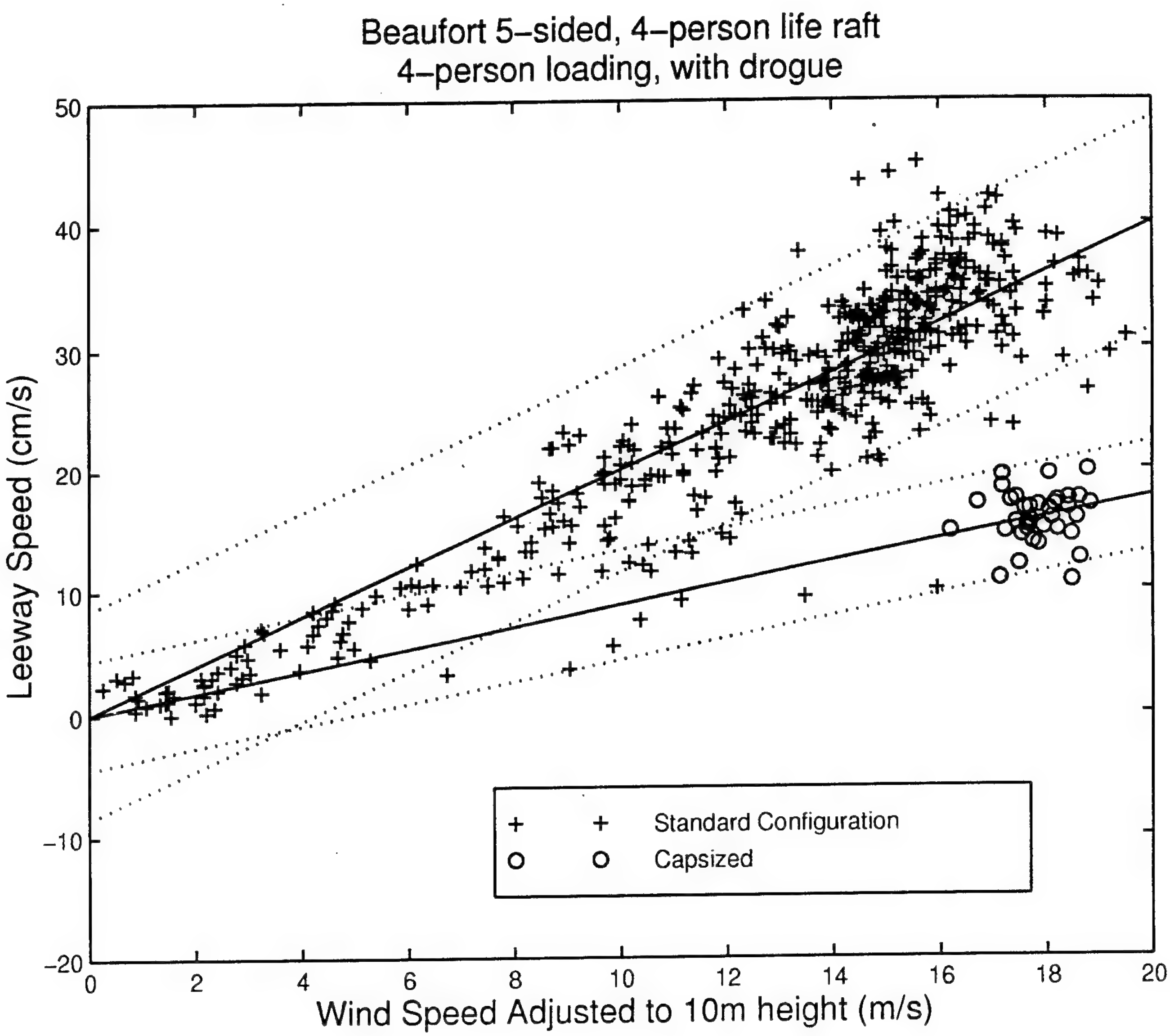


Figure 4-48. The Constrained Linear Regression and 95% Predictions Limits of Leeway Speed versus Wind Speed at 10m, Beaufort Five-Sided, 4-Person Life - Standard Configuration (+) and when the Life Raft was Capsized (o).

# CHAPTER 5

# CONCLUSIONS AND RECOMMENDATIONS

## 5.1 SUMMARY

This field experiment was conducted using an open wooden boat and two 6-person maritime life rafts. It was the first leeway study of the Switlik 6-person, 8-sided canopied life raft with a full toroidal ballast bag. During this study, leeway data was collected at higher wind speeds (**$W_{10m}$** up to 22.2 m/s) than during previous leeway studies (**$W_{10m}$** typically less than 15 m/s). Leeway data for both the standard configuration and swamped or capsized conditions of these three targets are included in this study. The portion of leeway data from a third life raft (the Beaufort 4-person raft from Run 22) when it was capsized, collected during a previous study, was also included in this analysis. The mean leeway rates are summarized in Table 5-1 for these four craft in their standard configuration and when swamped or capsized. Section 5-4 summarizes the leeway equations for manual and numerical search planning tools.

Table 5-1
Summary of Mean Leeway Rates

| Leeway Craft | Orientation | Mean Leeway Rate (percent of **$W_{10m}$**) | Mean Leeway Rate as a Percentage of Std.. Configuration |
|---|---|---|---|
| 5.5m wooden-plank open boat | Std. Configuration | 3.65 | 47% |
| | Swamped | 1.73 | |
| Switlik 6-Person life raft "J" Full Toroidal Bag | Std. Configuration | 1.95 | 41% |
| | Swamped | 0.79 | |
| Switlik 6-Person life raft "H" 4 small ballast bags | Std. Configuration | 2.82 | 40% |
| | Capsized | 1.13 | |
| Beaufort 5-sided 4-person life raft | Std. Configuration | 1.93 | 46% |
| | Capsized | 0.89 | |

## 5.2 IMPLICATIONS FOR SEARCH PLANNING OF SWAMPING AND CAPSZING EVENTS

When a life raft or small boat swamps or capsizes its leeway rate drops to 40 to 47 percent of its original value as shown in Table 5-1. This represents a significant reduction to the

leeway speed of a search target. The leeway information presently available in CASP and the SAR Manual is based on studies conducted during moderate wind conditions. The current SAR Manual guidance is to use the leeway equations provided for wind up to 40 knots (20.5 m/s) to predict the leeway of life rafts and other craft. **In heavy weather**, life rafts and small boats may swamp, capsize or sink. Under these circumstances, direct application of the leeway equations in **CASP and the SAR Manual would greatly over-estimate the drift of those survivor craft that swamp or capsize**.

## 5.3 SUMMARY OF CONDITIONS WHEN CRAFT SWAMPED OR CAPSIZED

The 1995 field experiment added three documented and two undocumented instances of swamping, capsizing, or sinking to the list of such events that had occurred in 1992 and 1993. The initial table of swamped, capsized, or sunk leeway targets (Table 1-2) was therefore updated to include the 1995 data and appears below as Table 5-2. During two leeway runs (22 and 54) where a 4-person life raft swamped or capsized, there was a concurrent leeway run (23 and 55) where a nearby 4-person life raft did not swamp or capsize. The craft that did not capsize or swamp provided nearby measurements of wind speed and direction for the analyses of the swamped or capsized portions of leeway runs. Table 5-3 shows the distance between the those craft that swamped or capsized and the craft which did not. Leeway Runs # 25, 51 and 64 did not have a concurrent leeway run. Leeway Runs # 60, 61, 62 and 63 were all concurrent and all craft either swamped, capsized or eventually sank. Thus, Tables 5-2 and 5-3 provide a start for developing the probabilities of occurrence of swamping and capsizing events.

The time series of the 10-meter wind speed and significant wave height (Figures 5-1, 5-2 and 5-3) data associated with these events show that the swamping and capsizing events did not occur at the times of maximum wind speed and wave height. In Figures 5-1, 5-2, and 5-3 the swamping, capsizing and sinking events are indicated by vertical lines.

**The prediction of swamping or capsizing events is essential for the proper incorporation of this information into search planning.** That the swamping and capsizing events are not a simple function of wind speed or wave height suggests that this is an area that will require further investigation to determine what environmental factors or combination thereof directly affect life raft and small craft stability and sea-worthiness.

Table 5-2
Summary of 1992, 1993 and 1995 Swamping, Capsizing and Sinking of Leeway Targets

| Leeway Craft | Leeway Run # | Event | Time of Event (UTC) | Hours after Deployment | 10m Winds (m/s) | Wave Height (m) |
|---|---|---|---|---|---|---|
| Beaufort life raft 4-person loading, drogue | 22 | Capsized | 07:00 6 DEC 92 | 81 | 17.2 | 4.3 |
| Tulmar life raft 4-person loading, drogue | 25 | Capsized | 00:10 13 DEC 92 | 57 | 13 | 5 |
| L1011 Aircraft Slide Raft | 51 | Sunk | 08:20 11 DEC 93 | 15 | 8 | 3 - 3.5 |
| Beaufort life raft 1-person loading, no drogue | 54 | Capsized | 21:00 16 DEC 93 | 27 | 15 | 5 - 6 |
| 5.5m open boat #1 | 60 | Swamped | 22:50 28 NOV 95 | 56 | 16.2 | 3.4 - 3.9 |
| 5.2m open boat #2 | 61 | Assumed Sunk | NOV 95 | unknown | N/A | N/A |
| 5m open boat #3 | 62 | Assumed Sunk | after 14:51 30 NOV 95 | after 115 hours | 7.5 | 4.5 |
| Switlik 6-Person life raft "J" | 63 | Swamped | 22:30 28 NOV 95 | 55.5 | 16.1 | 3.5 |
| Switlik 6-Person life raft "H" | 64 | Capsized | 18:50 2 DEC 95 | 47.5 | 16.7 | 5.6 - 5.9 |

Table 5-3
Summary of Leeway Craft that Did Not Swamp, Capsize or Sink
When a Concurrent - Nearby Leeway Craft Did Swamp, Capsize or Sink

| Leeway Craft | Leeway Run # | Event | Time of Event (UTC) | Related Run # and Distance from Capsized craft | 10m Winds (m/s) | Wave Height (m) |
|---|---|---|---|---|---|---|
| Tulmar 4-person life raft, 1person loading, no drogue | 23 | Did Not Capsize | 07:00 6 DEC 92 | #22 17 km | 17.2 | 4.3 |
| Beaufort 6-sided, 4-person life raft, 1 person loading, no drogue | 55 | Did Not Capsize | 21:00 16 DEC 93 | #54 13 km | 15 | 5 - 6 |

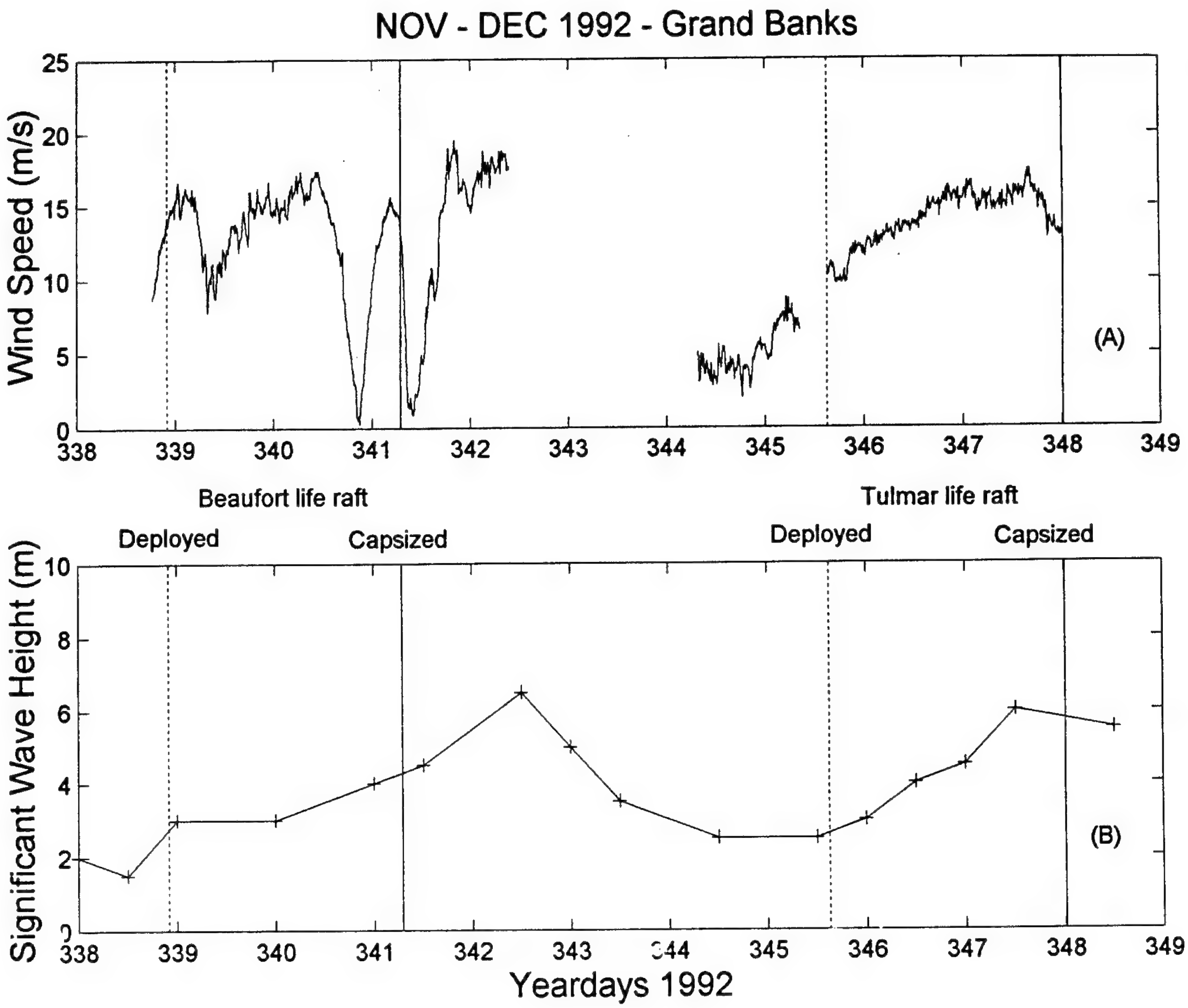


Figure 5-1. Time Series of Wind Speed (A) and Significant Wave Height (B) from the 1992 Leeway Field Experiment on the Grand Banks of Newfoundland. Wind data is from three leeway craft adjusted to 10m height. Wave data is from AES 12-hourly analyses and forecasts and the weather log aboard the SIR HUMPHREY GILBERT (crosses). Vertical lines are deployment (dotted) and capsizing events (solid) of Beaufort and Tulmar Life Rafts.

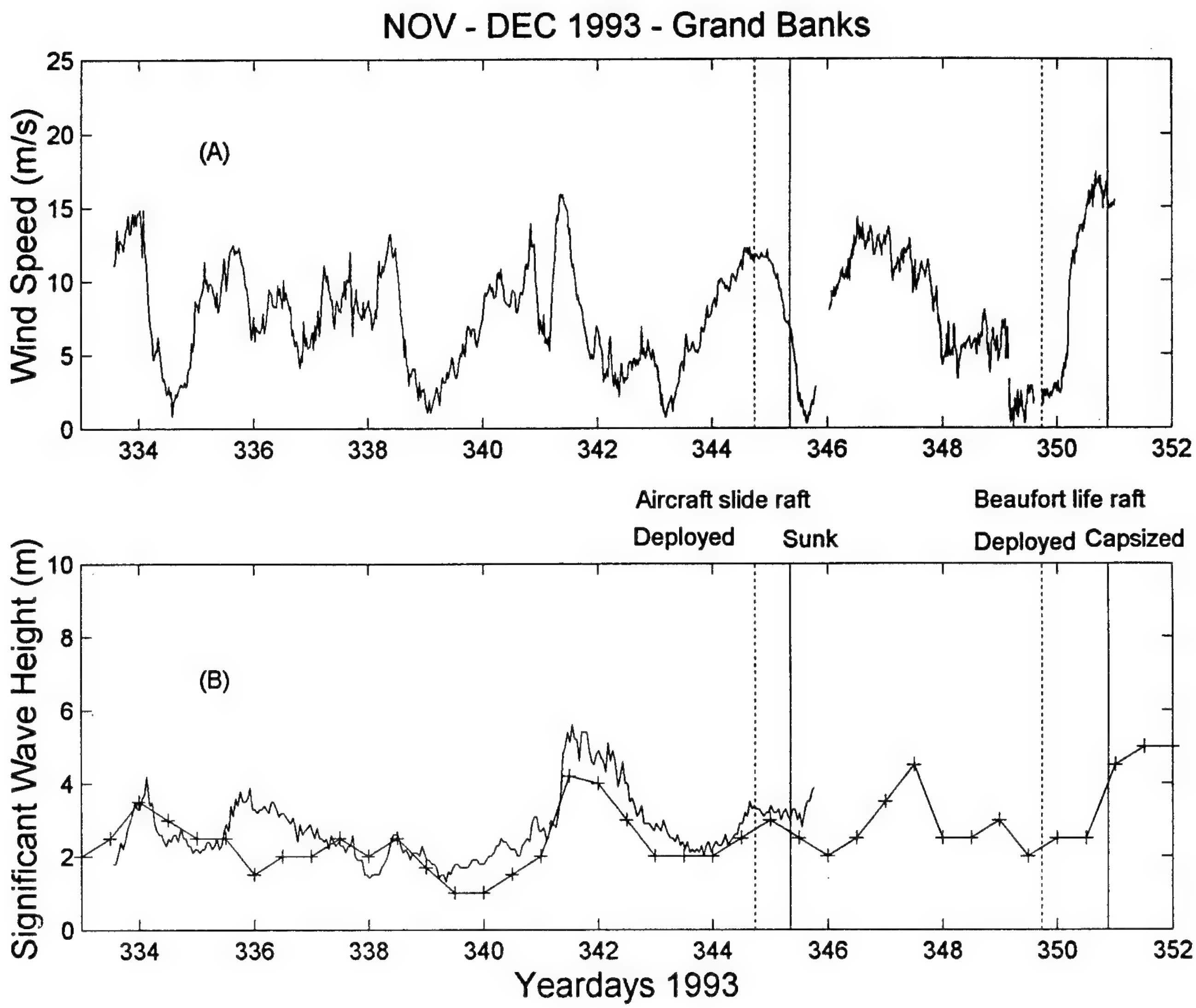


Figure 5-2. Time Series of Wind Speed (A) and Significant Wave Height (B) from the 1993 Leeway Field Experiment on the Grand Banks of Newfoundland. Wind data is from the MiniMet® Buoy, and from three leeway craft - adjusted to 10m height. Wave data is from the MiniMet® Buoy and from AES 12-hourly analyses and forecasts (crosses). Vertical lines are deployment (dotted) and sinking and capsizing events (solid) of an aircraft slide raft and a Beaufort Life Raft.

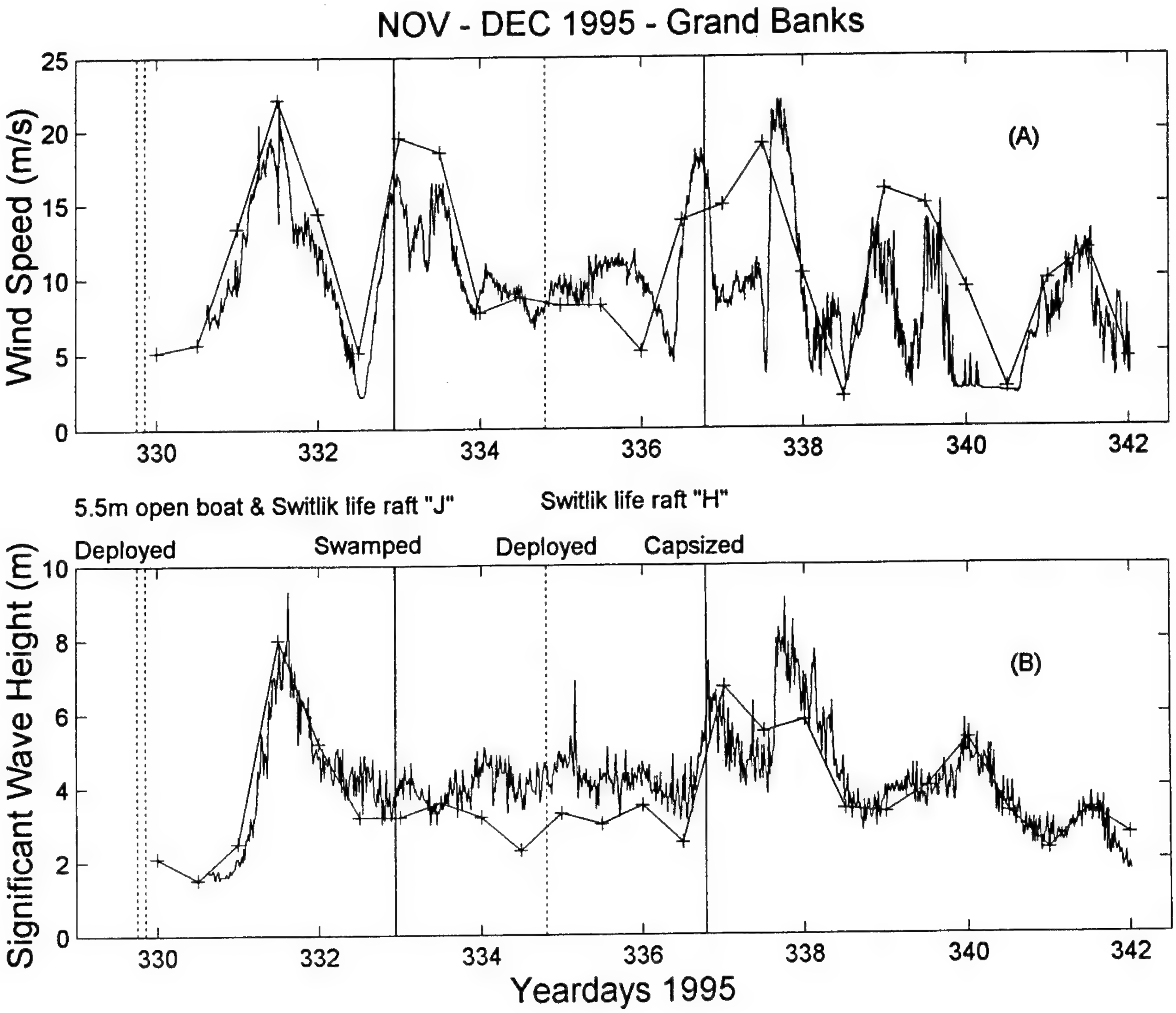


Figure 5-3. Time Series of Wind Speed (A) and Significant Wave Height (B) from the 1995 Leeway Field Experiment on the Grand Banks of Newfoundland Wind data is from the MiniMet® Buoy - adjusted to 10m height and from AES 12-hourly analyses and forecasts (crosses). Wave data is from the MiniMet® Buoy and from AES 12-hourly analyses and forecasts (crosses). Vertical lines are deployment (dotted) and swamping and capsizing events (solid) of an open boat and two Switlik Life Rafts.

## 5.4 RECOMMENDATIONS

### 5.4.1 Simple Models of Leeway for Manual Search Planning

Two separate versions of simple leeway models are recommended for use in manual search planning and for manual input to "User Defined Leeway" in the present version of CASP. Both simple models are based upon: (1) a constrained linear function of leeway speed on wind speed; (2) an uncertainty of the leeway speed based upon the standard crror; (3) twice the standard deviation of the leeway angle about the downwind direction and (4) the mean leeway angle. When the constrained linear function was not statistically valid, the mean leeway rate and twice the standard deviation of the leeway rate were substituted into the simple leeway model. This model applies when winds are less than 20m/s (40 knots).

Table 5-4 provides recommended coefficients for simple equations that model the leeway of both the standard configuration and the swamped or capsized versions of drifting craft. These coefficients are presented in the format of CASP "User Defined Leeway" input. For Table 5-4 only, wind speed and leeway speed have units of knots. For a complete discussion of "User Defined Leeway" in CASP, see Allen and Staubs (1997) which is included in Appendix A. In the present version of CASP, User Defined Leeway mean leeway angle is fixed at zero degrees, directly downwind; there is no provision to input a mean leeway angle.

The recommended manual equation coefficients are presented in Table 5-5 for the four craft. The sources of the data are the same as for Table 5-4 and are listed in the six notes for Table 5-4. The coefficients for manual equations in Table 5-5 are based upon wind speed having units of meters per second and leeway speed having units of centimeters per second. For manual solutions a mean downwind direction and a maximum / minimum leeway angle based upon two standard deviations are recommended for implementation.

Table 5-4
Summary of Recommended CASP "User Defined Leeway" Equations Coefficients
where
Leeway Speed and 10m Wind Speed are both expressed in **knots**

| CLASS | CRAFT | Multiplier | Uncertainty | Divergence |
|---|---|---|---|---|
| 5.5m wooden planked open boat | Std. Configuration<br>Swamped | 0.034 [1]<br>0.017 [3] | 0.13<br>0.53 | 20° [2]<br>20° [4] |
| Switlik 6 Person life raft w/Full toroidal ballast bag | Std. Configuration<br>Swamped | 0.018 [1]<br>0.008 [1] | 0.18<br>0.25 | 11° [2]<br>11° [4] |
| Switlik 6 Person life raft w/four small ballast bags | Std. Configuration<br>Capsized | 0.026 [1]<br>0.012 [1] | 0.16<br>0.20 | 11° [5]<br>11° [4] |
| Dunlop-Beaufort 5-sided, 4-Person 4-person loading, w/ drogue life raft | Std. Configuration | 0.020 [1] | 0.22 | 16° [6] |
| | Capsized | 0.009 [1] | 0.25 | 16° [4] |

Note (1) The Multiplier and Uncertainty values are based upon the constrained linear regression of leeway speed upon $\mathbf{W_{10m}}$ and the standard error of estimate match at 10.1 m/s (19.6 knots) of wind, following Allen and Staubs (1997).

Note (2) Twice the standard deviation of the leeway angle (from Tables 4-2, winds greater than 5 m/s; and Table 4-22, this report).

Note (3) The Multiplier and Uncertainty values are based upon the mean leeway rate and two standard deviations of the leeway rate, (Table 4-18, this report).

Note (4) There were no data collected on the leeway angle of the swamped/capsized target type and therefore the leeway angle values presented in this table were assumed to the same as the standard configuration for that target type.

Note (5) The value for Divergence is twice the standard deviation of the leeway angle (from Fitzgerald (1995), Table B4.7).

Note (6) The value for Divergence is twice the standard deviation of the leeway angle for winds greater than 10 knots, (Fitzgerald et al. (1994), Table 4.15).

Table 5-5
Summary of Recommended Manual Leeway Equations Coefficients
where
Leeway Speed (**L**) is expressed in cm/s and 10m Wind Speed ($\mathbf{W_{10m}}$) has units of m/s,

$$\mathbf{L},\ (cm/s) = \text{Multiplier} * \mathbf{W_{10m}}\ (m/s)$$

$$\mathbf{L}\ \text{max.}\ (cm/s) = \text{max. slope} * \mathbf{W_{10m}}\ (m/s)$$

$$\mathbf{L}\ \text{min.}\ (cm/s) = \text{min. slope} * \mathbf{W_{10m}}\ (m/s)$$

| CLASS | CRAFT | Multiplier | Uncertainty (max. & min. slopes) | Mean Angle (degrees) | Divergence (max. & min. Leeway angles) |
|---|---|---|---|---|---|
| 5.5m wooden planked open boat | Std. Config. | 3.37 | 4.25<br>2.49 | -4° | +16°<br>-24° |
| | Swamped | 1.73 | 2.65<br>0.81 | -4° | +16°<br>-24° |
| Switlik 6 Person life raft w/Full toroidal ballast bag | Std. Config. | 1.82 | 2.46<br>1.18 | +8° | +19°<br>-3° |
| | Swamped | 0.82 | 1.22<br>0.42 | +8° | +19°<br>-3° |
| Switlik 6 Person life raft w/four small ballast bag | Std. Config. | 2.59 | 3.39<br>1.79 | +23° | +34°<br>+12° |
| | Capsized | 1.17 | 1.63<br>0.71 | +23° | +34°<br>+12° |
| Dunlop-Beaufort 5-sided, 4-Person 4-person loading, w/ drogue life raft | Std. Config. | 2.00 | 2.84<br>1.16 | +12° | +38°<br>-4° |
| | Capsized | 0.88 | 1.30<br>0.46 | +12° | +38°<br>-4° |

### 5.4.2 Leeway Models for Implementation into Computerized Numerical Search Planning Tools

#### 5.4.2.1 Target Configurations with Insufficient Leeway Component Data

The simple models given in Table 5-5 are recommended for implementation into the numerical search models for swamped or capsized craft, since there was not any data collected on the leeway components of the swamped or capsized 5.5m open boat and life rafts, nor the Switlik 6-Person life raft with four small ballast bags in the standard configuration.

#### 5.4.2.2 5.5m Wooden-Planked Open Boat - Standard Configuration

The statistical models of the leeway components and their prediction limits for the Standard Configuration 5.5m wooden-planked open boat are recommended for implementation in numerical search planning models.

For the Standard Configuration 5.5m wooden-planked open boat, the piece-wise unconstrained regression model (illustrated in Figure 4-20) is recommended when the wind speed is less than 20 m/s (40 knots). Mean regression and upper and lower 95% prediction limit equations for predicting the downwind and crosswind leeway components of this craft relative to $\mathbf{W_{10m}}$ are presented in Table 5-6. The downwind component of leeway is shown to be a linear function of wind speed for winds up to 20 m/s. For the crosswind component of leeway, two sets of equations are presented in a piece-wise model. When the boat has the wind coming over the starboard side (positive relative wind directions) and the wind speed is between 0 and 20 m/s, then the negative **CWL** equation can be used. When the wind is from port (negative relative wind directions) and greater than 4.2 m/s, then the positive CWL equation can be used. Since search planners have no knowledge of the relative wind direction at an actual open boat in distress, guidance is required to estimate the frequency of shifting between the two possible **CWL** regression lines and their associated 95% prediction limits. From this study, it was estimated that the relative wind changed direction across the stern of the boat (jibbing) at periods less than 65 minutes fifty percent of the time, and 95 percent of time the jibbing occurred within a period of 46 hours.

Table 5-6
Summary of 5.5m Wooden-Planked Open Boat
Leeway Equations and Coefficients for Numerical Search Models

**DWL** = Downwind Component of Leeway (cm/s)
**CWL** = Crosswind Component of Leeway (cm/s)
$\mathbf{W_{10m}}$ = 10m Wind Speed (m/s)
$c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3
95% Prediction limit $\cong c_1*(\mathbf{W_{10m}})^2 + c_2*(\mathbf{W_{10m}}) + c_3$

| 5.5m Wooden-Planked Open Boat - Standard Configuration (0 to 20 m/s $\mathbf{W_{10m}}$) | | | | | | |
|---|---|---|---|---|---|---|
| Mean **DWL** = 2.87% $\mathbf{W_{10m}}$ + 4.0 cm/s<br>Mean +**CWL** (Neg. Rel. Wind Dir.) = 0.32% $\mathbf{W_{10m}}$ -2.9 cm/s [for $\mathbf{W_{10m}}$ 4.2 - 20 m/s]<br>Mean - **CWL** (Pos. Rel. Wind Dir.) = -0.62% $\mathbf{W_{10m}}$ +1.0 cm/s [for $\mathbf{W_{10m}}$ 0 - 20 m/s] | | | | | | |
| Dependent Variable | Upper Limits | | | Lower Limits | | |
| | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| **DWL** | 0.0002 | 2.87 | 10.53 | -0.0002 | 2.88 | -2.56 |
| **+CWL** (Neg. Rel. Wind Dir.) | 0.0003 | 0.317 | 2.06 | -0.0003 | 0.328 | -7.91 |
| **-CWL** (Pos. Rel. Wind Dir.) | 0.0007 | -0.634 | 7.08 | -0.0007 | -0.612 | -5.01 |

5.4.2.3 Switlik 6-Person Life Raft with Full Toroidal Ballast Bag and Canopy, Standard Configuration, 1-Person Loading, Drogued

For the Switlik 6-Person life raft with Full Toroidal Ballast Bag with Intact Canopy the unconstrained linear regression models of leeway components is recommended when wind speeds are less than 20m/s. Mean regression and upper and lower 95% prediction limit equations for computing the downwind and crosswind leeway components of this craft relative to $\mathbf{W_{10m}}$ are presented in Table 5-7, and were illustrated in Figures 4-29 and 4-32 or combined together in Figure 4-37.

Table 5-7

Summary of
Switlik 6-Person Life Raft with Full Toroidal Ballast Bags
Standard Configuration with Canopy Intact
Leeway Equations and Coefficients for Numerical Search Models

**DWL** = Downwind Component of Leeway (cm/s)
**CWL** = Crosswind Component of Leeway (cm/s)
$\mathbf{W_{10m}}$ = 10m Wind Speed (m/s)
$c_1$, $c_2$, and $c_3$ are coefficients from Eq. 3-3
95% Prediction limit $\cong c_1*(\mathbf{W_{10m}})^2 + c_2*(\mathbf{W_{10m}}) + c_3$

| Switlik 6-Person Life Raft with Full Toroidal Ballast Bags<br>Standard Configuration with Canopy Intact | | | | | | |
|---|---|---|---|---|---|---|
| Mean **DWL** = 1.65% $\mathbf{W_{10m}}$ + 4.2 cm/s<br>Mean **+CWL** = 0.23% $\mathbf{W_{10m}}$ + 0.5 cm/s<br>Mean **-CWL** = -0.23% $\mathbf{W_{10m}}$ - 0.5 cm/s | | | | | | |
| Dependent Variable | Upper Limits | | | Lower Limits | | |
| | $c_1$ | $c_2$ | $c_3$ | $c_1$ | $c_2$ | $c_3$ |
| **DWL** | 0.0007 | 1.64 | 7.79 | -0.0007 | 1.67 | 0.61 |
| **+CWL** | 0.0008 | 0.24 | 4.72 | -0.0008 | 0.28 | -3.66 |
| **-CWL** | 0.0008 | -0.28 | 3.66 | -0.0008 | -0.24 | -4.72 |

## 5.5 FUTURE WORK IN HEAVY WEATHER LEEWAY

An understanding of the behavior of survivor craft in heavy weather is critical to accurate prediction of the leeway drift for those survivor craft. The prediction of swamping and capsizing events will require further investigation to determine what environmental factors or combinations thereof directly affect life raft and small craft stability and sea-worthiness. Swamping and capsizing events are not a simple function of wind speed or wave height. When a determination is made as to what readily available environmental field data product(s) can accurately predict when life rafts and small craft change phase from a standard configuration to swamped or capsized leeway targets, then swamping and capsizing events can be incorporated into search planning. The present research goal should be to develop a readily available or measurable environmental data product(s) that can be used to accurately predict the conditions when life rafts and small craft may swamp or capsize. The instrument packages that the USCG R&D Center places aboard medium to large leeway targets have been upgraded to include tilt and roll sensors. These sensors will provide direct data on the attitude of the craft that are capable of measuring a complete roll over event when a craft capsizes. The Coast Guard should continue to pursue research into the leeway of common search targets during heavy weather conditions.

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APPENDIX A

## CASP User Defined Leeway Input for Maritime Life Rafts

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## 1. DEFINITIONS

The present version of the CASP (Computer Assisted Search Planning) program has eight predefined categories of leeway targets to choose from plus a "User Defined Leeway" option. User Defined Leeway allows the search planner to input values other than those provided in the eight pre-defined drift object categories. The eight categories follow guidance provided in the Leeway Table of the National SAR Manual.

After selecting the "User Defined Leeway" option in the GDOC "CASP Situation" dialog box, values for three parameters must be provided by the search planner. These parameters are referred to as Multiplier, Speed Uncertainty and Divergence.

The Multiplier is a factor by which the wind speed is multiplied to reduce the wind speed to leeway speed, as shown in equation 1.

$$\text{Leeway Speed} = \text{Multiplier} * \text{Wind Speed} \tag{1}$$

The Multiplier is the best-fit slope, computed by linear regression constrained through the origin, of the leeway speed versus wind speed relationship determined from actual leeway drift data.

The Speed Uncertainty is a factor by which a range of Multiplier values are generated. The Speed Uncertainty is used to compute reasonable upper and lower bounds on the Multiplier (slope) value as shown in equation 2. It is important to note that the term "Speed Uncertainty" used in GDOC is somewhat misleading in that its value is actually used to compute bounds on the *slope* of the leeway speed versus wind speed relationship. Thus, the Speed Uncertainty is *not* a direct measure of leeway speed error as its name implies.

$$\text{Slope Uncertainty Range} = \text{Multiplier} \pm (\text{Multiplier} * \text{Uncertainty}) \quad (2)$$

For each time step and target replication, CASP calculates leeway speed for the drifting object by randomly selecting a value within the Slope Uncertainty Range from a uniform distribution and then multiplying that value times the wind speed.

For example, if the search planner input a Multiplier of 0.05 and a Speed Uncertainty factor of 0.1, this would correspond to an object drifting at 5 percent of the wind speed with a Slope Uncertainty Range between 4.5 and 5.5 percent of the wind speed. For each time step and each target replication, CASP would randomly select a value between 0.045 and 0.055 to multiply times the wind speed to determine the speed of the drifting object through the water.

The Divergence is the maximum leeway angle off the downwind direction. Divergence is measured in units of degrees. For each CASP target replication for a drifting object, a leeway angle is chosen randomly from a uniform distribution between the positive and negative maximum leeway angle, as shown in equations 3 and 4, and this becomes the Divergence Angle for that replication.

$$\text{Maximum Positive Leeway Angle} = +\text{Divergence} \quad (3)$$
$$\text{Maximum Negative Leeway Angle} = -\text{Divergence} \quad (4)$$

## 2. RECOMMENDED LEEWAY DATA FOR LIFE RAFTS

Recent field experiments by the Canadian and U. S. Coast Guards have been conducted to measure the leeway drift of 4- to 6- person and 20-person maritime life rafts. Descriptions and drawings of the rafts and the results are presented in Fitzgerald et al. (1993) and in Fitzgerald et al. (1994). The values recommended for input as User Defined Leeway for 4- to 6- person life rafts are summarized in Table 1. Table 2 summarizes the values recommended for 20-person life rafts. Fitzgerald et al. (1993) and (1994) adjusted wind speed to the standard 10 meter height under neutral conditions using the Smith (1988) algorithm.

Table 1
Values for User Defined Leeway (CASP 1.1B)
4- to 6- Person Marine Life Rafts
with Full/Deep (Icelandic) Ballast Bags and a Canopy

| 4- to 6- Person Life Rafts w/Ballast Bags and Canopy | | Multiplier | Uncertainty | Divergence |
|---|---|---|---|---|
| Loading (Persons) | Drogue (Yes/No) | | | |
| 4 | Yes | 0.020 [1] | 0.3 [1] | 16 [2] |
| 4 | No | 0.035 [3] | 0.1 [3] | 8 [4] |
| 1 | Yes | 0.018 [5] | 0.1 [5] | 16 [5] |
| 1 | No | 0.036 [6] | 0.3 [6] | 16 [7] |

Table 2
Values for User Defined Leeway (CASP1.1B)
20- Person Marine Life Rafts
with Full/Deep (Icelandic) Ballast Bags and a Canopy

| 20- Person Life Rafts w/Ballast Bags and Canopy | | Multiplier | Uncertainty | Divergence (Degrees) |
|---|---|---|---|---|
| Loading (Persons) | Drogue (Yes/No) | | | |
| 20 | Yes | 0.027 [8] | 0.26 [8] | 12 [9] |
| 4 | No | 0.036 [10] | 0.16 [10] | 12 [11] |

## 3. TECHNICAL BACKGROUND

Multiplier values were determined by linear regression constrained through the origin of leeway speed versus wind speed adjusted to the 10 meter height. Most wind products (e.g. FNMOC winds) are adjusted to 10 meter height under neutral stability conditions, while raw wind sources are from the height of the anemometer and not adjusted upwards or downwards.

Speed (slope) Uncertainty values were matched to the 95 percent confidence limits on the constrained linear regression of leeway speed versus wind speed at a wind speed value of 19.6 knots. These limits were calculated as shown below using the standard error of the regression estimate ($S_{y/x}$) and the Student's T value for the 95-percent confidence limits on a normal distribution. The Student's T value for a 95 percent confidence level is 1.96. When these values are input to equation 5, the Speed (slope) Uncertainty value becomes 0.1 times ($S_{y/x}$) divided by the Multiplier value, as shown in equation 6.

$$\text{Uncertainty} = \frac{\text{Student's T(0.05 Confidence, Normal Distribution)}^* (S_{y/x})}{[(\text{Wind speed})^* \text{ Multiplier}]} \quad (5)$$

$$\text{Uncertainty} = (1.96)^*(S_{y/x})/[(19.6 \text{ knots})^*(\text{Multiplier})] = 0.1^*((S_{y/x})/\text{Multiplier}) \quad (6)$$

The choice of 19.6 knots wind speed provided a computationally-convenient estimate of regression line slope uncertainty near the middle of both the wind speed range of operational interest and of the wind speeds encountered during most leeway experiments (from which the values of ($S_{y/x}$) were derived). Therefore, at wind speeds near 20 knots (10m/s) there should be a good match between the Slope Uncertainty Range (calculated from equation 2) and the 95 percent confidence limits on actual field test data. However, the Slope Uncertainty Range computed in CASP will tend to underestimate the error at low wind speeds and overestimate the error at high wind speeds.

Divergence was defined as being equal to two standard deviations of the leeway angle data collected for wind speeds 10 knots and higher. Plus and minus two standard deviations includes 95.4 percent of a normal distribution. The leeway angle was limited to winds above 10 knots because there is excessive noise in the leeway angle data at low wind speeds.

## NOTES ON THE SOURCES OF THE VALUES IN TABLES 1 AND 2

[1] The Multiplier and Uncertainty values for this class are from a Beaufort 4-person 5-sided life raft, studied by Fitzgerald et al. (1994), page 69, Table 4.12.

[2] The Divergence angle for this class is from a Beaufort 4-person 5-sided life raft, studied by Fitzgerald et al. (1994), page 70, Table 4.14.

[3] The Multiplier and Uncertainty values for this class are from a Tulmar 4-person 12-sided life raft, studied by Fitzgerald et al. (1994), page 77, Table 4.19.

[4] The Divergence angle for this class is from a Tulmar 4-person 12-sided life raft, studied by Fitzgerald et al. (1994), page 78, Table 4.21.

[5] The values for this class are from a Tulmar 4-person 12-sided life raft, data collected during Leeway Run 5, and analyzed for this report.

[6] The Multiplier and Uncertainty values for this class are from a Tulmar 4-person 12-sided life raft, a Beaufort 4-person 5-sided life raft, and a Beaufort 4-person 6-sided life raft studied by Fitzgerald et al. (1994), page 52, Table 4.4.

[7] The Divergence angle for this class is from a Tulmar 4-person 12-sided life raft, a Beaufort 4-person 5-sided life raft, and a Beaufort 4-person 6-sided life raft studied by Fitzgerald et al. (1994), page 57, Table 4.8.

[8] The Multiplier and Uncertainty values for this class are from a Beaufort 20-person round life raft, studied by Fitzgerald et al. (1994), page 69, Table 4.12.

[9] The Divergence angle for this class is from a Tulmar 20-person round life raft, studied by Fitzgerald et al. (1994), page 70, Table 4.15.

[10] The Multiplier and Uncertainty values for this class are from a Beaufort 20-person round life raft, studied by Fitzgerald et al. (1994), page 52, Table 4.4.

[11] The Divergence angle for this class is from a Tulmar 20-person round life raft, studied by Fitzgerald et al. (1994), page 57, Table 4.8.

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Fitzgerald, R.B., D.J. Finlayson, and A. Allen. 1994. "Drift of Common Search and Rescue Objects - Phase III" Contract report prepared for Canadian Coast Guard, Research and Development, Ottawa, TP# 12179.

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U.S. Coast Guard, Commandant Instruction M16120.5A, "National Search and Rescue Manual," Washington D.C. 1 February 1991.

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APPENDIX B

LEEWAY DATA LISTING

This appendix list the 10-minute averaged leeway data from 1995 field experiment, and the capsized portion of the data record from the Leeway Run 22, collected in 1992. This Appendix has six sections of data listings.

Leeway Data Sections

| Section - Leeway Target Description | Pages |
|---|---|
| 5.5 meter wooden-planked open boat #1, standard configuration, 1-2 person loading, Leeway Run 60 | B2 - B9 |
| Switlik 6-person, eight-sided life raft "J" with full toroidal ballast bag, drogued, 1-person loading, standard configuration, Leeway Run 63 | B10 - B16 |
| 5.5 m open boat, Run 60, Swamped, and Switlik life raft "J", Run 63, Swamped | B17 - B25 |
| Switlik 6-person, 4-sided life raft "H" with four small ballast bags, drogued, 1-person loading, standard configuration, Leeway Run 64 | B26 - B31 |
| Switlik 6-person, 4-sided life raft "H" with four small ballast bags, drogued, capsized, Leeway Run 64 | B32 - B34 |
| Dunlop-Beaufort 4-person, 5-sided life raft with deep Icelandic ballast bags, 4-person loading, drogued, capsized, Leeway Run 22 | B35 |

There are eight different columns of data possible for each section. Data are 10-minute averages. The last four sections do not have wind direction data and therefore the crosswind and downwind components of leeway were not computed.

Column 1) The UTC time of the center of 10-minute data record in yearday (and decimal days).

Column 2) The Wind Speed adjusted to 10 meter height by Smith (1988) algorithm in meter per second.

Column 3) The Downwind Direction of the Wind in north coordinates (degrees).

Column 4) The Leeway Speed of the target in centimeters per second.

Column 5) The Eastward component of leeway of the target in centimeters per second.

Column 6) The Northward component of leeway of the target in centimeters per second.

Column 7) The Crosswind component of leeway of the target in centimeters per second.

Column 8) The Downwind component of leeway of the target in centimeters per second.

5.5m Open Boat, Std.Conf.Run 60

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 330.6215 | 7.74 | 288.66 | 31.26 | -30.61 | -6.36 | -15.81 | 26.97 |
| 330.6285 | 8.43 | 283.06 | 28.43 | -28.02 | -4.79 | -11.00 | 26.21 |
| 330.6354 | 8.43 | 284.16 | 24.84 | -24.42 | -4.53 | -10.37 | 22.57 |
| 330.6424 | 8.32 | 281.66 | 23.93 | -23.45 | -4.76 | -9.40 | 22.00 |
| 330.6493 | 7.63 | 281.76 | 25.94 | -25.88 | -1.68 | -6.92 | 25.00 |
| 330.6563 | 6.72 | 282.16 | 27.83 | -27.72 | -2.48 | -8.26 | 26.57 |
| 330.6632 | 6.95 | 283.36 | 31.65 | -31.38 | -4.08 | -11.22 | 29.59 |
| 330.6701 | 7.20 | 290.86 | 28.97 | -28.96 | -0.62 | -10.89 | 26.84 |
| 330.6771 | 7.20 | 290.66 | 28.49 | -28.49 | -0.20 | -10.24 | 26.59 |
| 330.6840 | 7.55 | 286.06 | 25.93 | -25.83 | -2.31 | -9.36 | 24.18 |
| 330.6910 | 7.55 | 286.96 | 24.37 | -24.34 | -1.22 | -8.27 | 22.92 |
| 330.6979 | 7.44 | 287.66 | 22.33 | -22.29 | -1.42 | -8.11 | 20.81 |
| 330.7049 | 7.56 | 286.26 | 22.85 | -22.81 | -1.21 | -7.55 | 21.56 |
| 330.7118 | 7.46 | 285.66 | 20.24 | -20.16 | -1.80 | -7.18 | 18.92 |
| 330.7188 | 7.81 | 287.66 | 22.23 | -22.02 | -3.05 | -9.58 | 20.05 |
| 330.7257 | 7.60 | 283.76 | 23.60 | -23.43 | -2.79 | -8.29 | 22.10 |
| 330.7326 | 7.26 | 278.96 | 27.07 | -26.60 | -5.05 | -9.12 | 25.49 |
| 330.7396 | 7.16 | 280.86 | 28.24 | -27.97 | -3.90 | -9.10 | 26.74 |
| 330.7465 | 7.40 | 283.16 | 29.08 | -29.07 | -0.88 | -7.48 | 28.10 |
| 330.7535 | 7.29 | 284.76 | 29.68 | -29.67 | -0.49 | -8.04 | 28.57 |
| 330.7604 | 6.95 | 280.26 | 27.93 | -27.91 | -1.04 | -5.99 | 27.28 |
| 330.7674 | 6.84 | 282.56 | 27.22 | -27.20 | -1.16 | -7.05 | 26.30 |
| 330.7743 | 7.31 | 282.96 | 30.99 | -30.87 | -2.76 | -9.61 | 29.46 |
| 330.7813 | 7.66 | 281.36 | 30.26 | -30.26 | 0.34 | -5.62 | 29.73 |
| 330.7882 | 7.79 | 284.46 | 27.42 | -27.42 | -0.17 | -7.00 | 26.51 |
| 330.7951 | 8.36 | 286.46 | 29.97 | -29.96 | -0.84 | -9.29 | 28.50 |
| 330.8021 | 8.85 | 288.96 | 28.16 | -28.12 | -1.56 | -10.61 | 26.08 |
| 330.8090 | 7.94 | 285.66 | 27.77 | -27.64 | -2.66 | -10.02 | 25.89 |
| 330.8160 | 8.30 | 287.66 | 26.45 | -26.41 | -1.47 | -9.41 | 24.72 |
| 330.8229 | 7.98 | 285.36 | 25.74 | -25.64 | -2.23 | -8.94 | 24.14 |
| 330.8299 | 8.31 | 285.46 | 27.28 | -27.05 | -3.50 | -10.58 | 25.14 |
| 330.8368 | 8.41 | 283.66 | 29.64 | -29.33 | -4.27 | -11.08 | 27.50 |
| 330.8438 | 8.86 | 285.26 | 32.91 | -32.24 | -6.63 | -14.88 | 29.36 |
| 330.8507 | 8.85 | 285.66 | 36.43 | -36.27 | -3.37 | -13.03 | 34.02 |
| 330.8576 | 8.86 | 287.06 | 39.33 | -39.31 | -1.42 | -12.88 | 37.16 |
| 330.8646 | 9.08 | 291.66 | 38.87 | -38.87 | 0.08 | -14.27 | 36.15 |
| 330.8715 | 9.21 | 294.96 | 37.98 | -37.76 | 4.05 | -12.26 | 35.95 |
| 330.8785 | 9.89 | 297.66 | 35.44 | -35.31 | 2.94 | -13.79 | 32.64 |
| 330.8854 | 10.12 | 300.66 | 36.09 | -35.90 | 3.77 | -15.06 | 32.80 |
| 330.8924 | 9.55 | 302.46 | 35.23 | -34.83 | 5.33 | -14.19 | 32.25 |
| 330.8993 | 9.55 | 306.46 | 38.45 | -38.19 | 4.52 | -19.05 | 33.40 |
| 330.9063 | 9.54 | 310.96 | 37.12 | -36.08 | 8.71 | -17.07 | 32.96 |
| 330.9132 | 9.32 | 309.96 | 34.58 | -33.38 | 9.02 | -14.53 | 31.38 |
| 330.9201 | 9.21 | 316.96 | 37.59 | -37.27 | 4.92 | -23.88 | 29.04 |
| 330.9271 | 9.32 | 317.76 | 38.48 | -37.53 | 8.52 | -22.05 | 31.54 |
| 330.9340 | 8.98 | 316.76 | 37.50 | -36.78 | 7.31 | -21.78 | 30.53 |
| 330.9410 | 8.98 | 312.36 | 34.00 | -33.08 | 7.84 | -16.50 | 29.73 |
| 330.9479 | 9.66 | 304.66 | 37.92 | -36.77 | 9.28 | -13.27 | 35.53 |

5.5m Open Boat, Std.Conf.Run 60

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 330.9549 | 9.54 | 306.06 | 41.73 | -39.19 | 14.34 | -11.47 | 40.12 |
| 330.9618 | 9.43 | 304.96 | 47.12 | -44.40 | 15.78 | -12.51 | 45.43 |
| 330.9688 | 10.12 | 310.66 | 37.50 | -35.35 | 12.52 | -13.53 | 34.97 |
| 330.9757 | 11.38 | 320.66 | 28.71 | -26.56 | 10.90 | -13.64 | 25.27 |
| 330.9826 | 9.14 | 316.16 | 31.26 | -29.35 | 10.77 | -13.70 | 28.10 |
| 330.9896 | 9.02 | 307.66 | 36.63 | -34.14 | 13.27 | -10.35 | 35.13 |
| 330.9965 | 8.91 | 303.66 | 34.39 | -32.45 | 11.39 | -8.51 | 33.32 |
| 331.0035 | 10.95 | 318.36 | 39.36 | -38.19 | 9.54 | -22.20 | 32.51 |
| 331.0104 | 9.33 | 316.36 | 45.52 | -44.21 | 10.84 | -24.51 | 38.36 |
| 331.0174 | 9.85 | 307.56 | 42.98 | -41.51 | 11.15 | -16.46 | 39.70 |
| 331.0243 | 9.59 | 304.26 | 39.74 | -36.83 | 14.93 | -8.39 | 38.85 |
| 331.0313 | 10.15 | 306.86 | 37.73 | -33.28 | 17.79 | -5.73 | 37.30 |
| 331.0382 | 10.72 | 312.46 | 26.92 | -20.48 | 17.47 | -0.94 | 26.91 |
| 331.0451 | 11.41 | 318.46 | 24.99 | -14.70 | 20.21 | 2.40 | 24.87 |
| 331.0521 | 11.54 | 321.16 | 30.12 | -18.45 | 23.81 | 0.57 | 30.12 |
| 331.0590 | 12.81 | 322.96 | 37.25 | -25.25 | 27.40 | -3.65 | 37.08 |
| 331.0660 | 13.16 | 322.76 | 49.46 | -38.30 | 31.31 | -11.54 | 48.10 |
| 331.0729 | 13.15 | 327.06 | 49.23 | -36.60 | 32.92 | -12.81 | 47.53 |
| 331.0799 | 13.26 | 323.76 | 45.89 | -35.84 | 28.67 | -11.95 | 44.31 |
| 331.0868 | 12.92 | 328.26 | 48.03 | -38.62 | 28.55 | -17.82 | 44.60 |
| 331.0938 | 12.93 | 328.66 | 48.00 | -38.33 | 28.89 | -17.71 | 44.62 |
| 331.1007 | 12.70 | 330.66 | 50.38 | -39.56 | 31.20 | -19.19 | 46.58 |
| 331.1076 | 12.25 | 330.96 | 49.43 | -40.22 | 28.72 | -21.22 | 44.64 |
| 331.1146 | 12.72 | 331.46 | 53.71 | -43.57 | 31.41 | -23.27 | 48.41 |
| 331.1215 | 12.71 | 327.56 | 56.65 | -46.96 | 31.68 | -22.64 | 51.93 |
| 331.1285 | 13.40 | 328.66 | 57.91 | -48.88 | 31.06 | -25.59 | 51.95 |
| 331.1354 | 14.45 | 331.06 | 57.45 | -47.08 | 32.94 | -25.26 | 51.61 |
| 331.1424 | 15.02 | 330.66 | 57.73 | -47.34 | 33.04 | -25.07 | 52.00 |
| 331.1493 | 15.02 | 330.36 | 58.80 | -49.56 | 31.63 | -27.43 | 52.01 |
| 331.1563 | 15.37 | 330.26 | 62.29 | -53.69 | 31.58 | -30.94 | 54.06 |
| 331.1632 | 15.83 | 331.36 | 58.73 | -50.55 | 29.90 | -30.03 | 50.47 |
| 331.1701 | 15.26 | 331.86 | 59.82 | -48.59 | 34.90 | -26.38 | 53.69 |
| 331.1771 | 15.84 | 330.56 | 58.77 | -47.14 | 35.09 | -23.80 | 53.73 |
| 331.1840 | 15.50 | 330.16 | 61.00 | -48.86 | 36.52 | -24.20 | 55.99 |
| 331.1910 | 15.50 | 329.46 | 62.22 | -51.06 | 35.56 | -25.90 | 56.58 |
| 331.1979 | 16.20 | 330.66 | 57.61 | -44.94 | 36.05 | -21.51 | 53.45 |
| 331.2049 | 15.61 | 330.86 | 59.13 | -44.90 | 38.46 | -20.49 | 55.46 |
| 331.2118 | 15.83 | 330.76 | 62.09 | -48.66 | 38.57 | -23.61 | 57.43 |
| 331.2188 | 16.41 | 331.16 | 59.48 | -45.35 | 38.49 | -21.16 | 55.59 |
| 331.2257 | 16.41 | 332.66 | 63.16 | -49.43 | 39.33 | -25.84 | 57.64 |
| 331.2326 | 16.30 | 332.06 | 60.75 | -47.63 | 37.71 | -24.40 | 55.64 |
| 331.2396 | 16.66 | 331.36 | 58.87 | -47.33 | 35.01 | -24.75 | 53.41 |
| 331.2465 | 16.54 | 331.36 | 56.20 | -44.30 | 34.58 | -22.30 | 51.59 |
| 331.2535 | 17.12 | 327.46 | 60.93 | -45.70 | 40.30 | -16.85 | 58.56 |
| 331.2604 | 16.66 | 329.96 | 50.36 | -28.72 | 41.37 | -4.14 | 50.19 |
| 331.2674 | 20.44 | 339.66 | 45.69 | -0.28 | 45.69 | 15.63 | 42.94 |
| 331.2743 | 17.21 | 333.86 | 50.74 | -0.73 | 50.73 | 21.70 | 45.86 |
| 331.2813 | 16.82 | 332.16 | 49.73 | -1.59 | 49.70 | 21.81 | 44.69 |

5.5m Open Boat, Std.Conf.Run 60

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 331.2882 | 17.04 | 334.96 | 54.67 | 1.27 | 54.66 | 24.29 | 48.98 |
| 331.2951 | 16.91 | 332.36 | 54.27 | -3.95 | 54.13 | 21.61 | 49.78 |
| 331.3021 | 17.15 | 334.46 | 53.02 | 0.02 | 53.02 | 22.88 | 47.83 |
| 331.3090 | 17.97 | 335.36 | 56.20 | 1.26 | 56.18 | 24.57 | 50.54 |
| 331.3160 | 17.63 | 335.36 | 54.04 | -1.72 | 54.01 | 20.96 | 49.81 |
| 331.3229 | 18.21 | 335.86 | 54.84 | -5.45 | 54.57 | 17.35 | 52.02 |
| 331.3299 | 18.21 | 337.16 | 56.20 | -22.45 | 51.52 | -0.69 | 56.20 |
| 331.3368 | 17.27 | 338.06 | 53.56 | -2.37 | 53.51 | 17.80 | 50.52 |
| 331.3438 | 17.85 | 337.66 | 53.78 | -0.75 | 53.78 | 19.76 | 50.02 |
| 331.3507 | 17.03 | 337.26 | 53.75 | -8.30 | 53.10 | 12.87 | 52.18 |
| 331.3576 | 18.20 | 336.06 | 54.52 | -5.74 | 54.22 | 16.76 | 51.88 |
| 331.3646 | 18.32 | 335.36 | 52.47 | -18.37 | 49.16 | 3.81 | 52.34 |
| 331.3715 | 19.02 | 336.76 | 66.94 | -49.96 | 44.55 | -28.32 | 60.65 |
| 331.3785 | 18.32 | 336.86 | 69.05 | -52.64 | 44.69 | -30.83 | 61.79 |
| 331.3854 | 18.44 | 338.66 | 68.79 | -52.09 | 44.93 | -32.16 | 60.81 |
| 331.3924 | 18.68 | 337.76 | 65.21 | -50.78 | 40.92 | -31.50 | 57.10 |
| 331.3993 | 19.39 | 338.56 | 63.42 | -49.12 | 40.12 | -31.05 | 55.30 |
| 331.4063 | 19.15 | 339.16 | 64.72 | -47.95 | 43.46 | -29.35 | 57.68 |
| 331.4132 | 19.50 | 338.46 | 63.91 | -50.61 | 39.03 | -32.74 | 54.89 |
| 331.4201 | 19.61 | 338.36 | 57.70 | -29.82 | 49.40 | -9.49 | 56.92 |
| 331.4271 | 18.56 | 338.26 | 48.85 | -5.86 | 48.50 | 12.52 | 47.22 |
| 331.4340 | 19.15 | 337.36 | 54.32 | 4.56 | 54.13 | 25.05 | 48.20 |
| 331.4410 | 18.80 | 337.46 | 52.81 | 8.48 | 52.13 | 27.82 | 44.89 |
| 331.4479 | 19.03 | 339.36 | 56.82 | 15.69 | 54.61 | 33.94 | 45.58 |
| 331.4549 | 18.68 | 342.56 | 57.57 | 22.24 | 53.10 | 37.14 | 44.00 |
| 331.4618 | 18.08 | 345.16 | 63.76 | 31.76 | 55.29 | 44.86 | 45.31 |
| 331.4688 | 18.08 | 348.66 | 60.11 | -3.46 | 60.01 | 8.41 | 59.52 |
| 331.4757 | 17.49 | 352.46 | 64.21 | -26.56 | 58.46 | -18.66 | 61.44 |
| 331.4826 | 17.84 | 359.36 | 62.86 | -31.89 | 54.17 | -31.28 | 54.52 |
| 331.4896 | 17.12 | 4.06 | 71.51 | -34.49 | 62.64 | -38.84 | 60.04 |
| 331.4965 | 17.10 | 4.06 | 61.32 | -7.54 | 60.86 | -11.82 | 60.17 |
| 331.5035 | 16.15 | 22.66 | 58.12 | 21.13 | 54.15 | -1.36 | 58.11 |
| | | Wind Direction | | | | Crosswind & | Downwind |
| | | Fails | | | | below are | Invalid |
| 331.5104 | 13.80 | 75.46 | 62.24 | 26.79 | 56.18 | | |
| 331.5174 | 22.16 | 77.66 | 55.44 | 25.44 | 49.26 | | |
| 331.5243 | 20.73 | 75.76 | 57.48 | 27.82 | 50.30 | | |
| 331.5313 | 20.01 | 66.06 | 61.13 | 29.17 | 53.72 | | |
| 331.5382 | 20.24 | 60.76 | 56.57 | 26.99 | 49.72 | | |
| 331.5451 | 19.52 | 64.36 | 60.63 | 32.44 | 51.22 | | |
| 331.5521 | 20.12 | 62.96 | 57.88 | 32.62 | 47.81 | | |
| 331.5590 | 19.41 | 64.16 | 56.91 | 26.48 | 50.37 | | |
| 331.5660 | 19.64 | 63.26 | 57.29 | 29.11 | 49.34 | | |
| 331.5729 | 18.93 | 65.86 | 59.60 | 1.08 | 59.59 | | |
| 331.5799 | 18.81 | 69.36 | 59.77 | -5.01 | 59.56 | | |
| 331.5868 | 19.02 | 73.76 | 60.94 | -8.82 | 60.30 | | |
| 331.5938 | 18.19 | 76.76 | 62.94 | -4.66 | 62.76 | | |
| 331.6007 | 18.20 | 74.56 | 56.74 | 1.02 | 56.73 | | |

5.5m Open Boat, Std.Conf.Run 60

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 331.6076 | 17.60 | 76.86 | 46.21 | 19.76 | 41.77 | | |
| 331.6146 | 17.95 | 77.66 | 35.71 | 27.70 | 22.54 | | |
| 331.6215 | 17.59 | 77.26 | 29.70 | 19.46 | 22.44 | | |
| 331.6285 | 17.35 | 82.26 | 36.22 | 19.70 | 30.40 | | |
| 331.6354 | 16.76 | 84.26 | 50.30 | 4.35 | 50.11 | | |
| 331.6424 | 16.87 | 86.86 | 52.51 | 13.69 | 50.69 | | |
| 331.6493 | 16.05 | 88.96 | 57.82 | 24.53 | 52.36 | | |
| 331.6563 | 15.81 | 93.66 | 57.47 | 31.38 | 48.14 | | |
| 331.6632 | 15.23 | 94.16 | 46.79 | 27.61 | 37.77 | | |
| 331.6701 | 14.06 | 98.86 | 51.29 | 36.39 | 36.15 | | |
| 331.6771 | 14.19 | 106.36 | 61.08 | 41.59 | 44.74 | | |
| 331.6840 | 14.07 | 108.76 | 69.60 | 43.53 | 54.31 | | |
| 331.6910 | 12.57 | 113.26 | 51.54 | 39.88 | 32.65 | | |
| 331.6979 | 13.38 | 117.16 | 46.85 | 39.24 | 25.61 | | |
| 331.7049 | 12.45 | 123.36 | 50.74 | 43.06 | 26.84 | | |
| 331.7118 | 12.90 | 128.16 | 47.64 | 37.22 | 29.74 | | |
| 331.7188 | 13.24 | 131.96 | 41.69 | 35.21 | 22.33 | | |
| 331.7257 | 13.82 | 137.66 | 46.60 | 42.96 | 18.07 | | |
| 331.7326 | 13.82 | 137.66 | 40.60 | 37.14 | 16.40 | | |
| 331.7396 | 13.00 | 138.86 | 38.05 | 35.64 | 13.35 | | |
| 331.7465 | 12.17 | 141.26 | 42.05 | 37.70 | 18.61 | | |
| 331.7535 | 12.99 | 140.46 | 46.51 | 41.26 | 21.47 | | |
| 331.7604 | 13.70 | 142.36 | 43.71 | 37.71 | 22.10 | | |
| 331.7674 | 13.11 | 145.06 | 46.71 | 40.38 | 23.49 | | |
| 331.7743 | 13.10 | 148.56 | 46.52 | 41.18 | 21.65 | | |
| 331.7813 | 13.44 | 148.46 | 42.63 | 38.41 | 18.48 | | |
| 331.7882 | 13.68 | 149.06 | 48.24 | 43.39 | 21.09 | | |
| 331.7951 | 13.56 | 151.86 | 41.40 | 37.95 | 16.54 | | |
| 331.8021 | 13.57 | 156.76 | 38.53 | 36.48 | 12.41 | | |
| 331.8090 | 12.86 | 160.16 | 41.42 | 37.39 | 17.82 | | |
| 331.8160 | 12.63 | 158.86 | 47.42 | 42.97 | 20.03 | | |
| 331.8229 | 12.28 | 159.66 | 46.82 | 42.42 | 19.80 | | |
| 331.8299 | 13.09 | 160.36 | 44.62 | 42.46 | 13.70 | | |
| 331.8368 | 14.61 | 161.96 | 38.67 | 37.42 | 9.76 | | |
| 331.8438 | 13.43 | 165.46 | 41.24 | 39.80 | 10.80 | | |
| 331.8507 | 13.32 | 166.96 | 41.23 | 40.10 | 9.62 | | |
| 331.8576 | 12.96 | 171.36 | 41.93 | 41.10 | 8.31 | | |
| 331.8646 | 13.08 | 172.56 | 46.95 | 44.42 | 15.21 | | |
| 331.8715 | 13.78 | 172.26 | 48.33 | 46.24 | 14.04 | | |
| 331.8785 | 14.24 | 173.86 | 43.13 | 42.42 | 7.79 | | |
| 331.8854 | 14.24 | 173.46 | 37.78 | 37.50 | 4.56 | | |
| 331.8924 | 13.29 | 179.76 | 35.47 | 35.11 | 5.04 | | |
| 331.8993 | 12.82 | 180.26 | 39.64 | 38.98 | 7.17 | | |
| 331.9063 | 11.88 | 184.76 | 45.43 | 44.54 | 8.94 | | |
| 331.9132 | 12.12 | 183.16 | 41.83 | 41.77 | 2.27 | | |
| 331.9201 | 13.40 | 183.66 | 39.90 | 39.87 | -1.39 | | |
| 331.9271 | 12.70 | 187.46 | 41.86 | 41.80 | -2.29 | | |
| 331.9340 | 13.16 | 188.76 | 41.23 | 41.19 | -1.90 | | |

5.5m Open Boat, Std.Conf.Run 60

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 331.9410 | 12.34 | 185.86 | 43.13 | 42.69 | 6.17 | | |
| 331.9479 | 12.69 | 183.76 | 44.41 | 43.54 | 8.72 | | |
| 331.9549 | 11.52 | 183.86 | 42.89 | 42.62 | 4.83 | | |
| 331.9618 | 11.98 | 188.66 | 35.78 | 35.70 | -2.33 | | |
| 331.9688 | 12.45 | 192.56 | 37.83 | 37.78 | -2.08 | | |
| 331.9757 | 12.32 | 192.76 | 38.01 | 37.96 | -2.00 | | |
| 331.9826 | 11.50 | 194.56 | 36.36 | 36.34 | 1.22 | | |
| 331.9896 | 10.68 | 199.46 | 39.23 | 38.94 | 4.75 | | |
| 331.9965 | 10.33 | 199.46 | 44.19 | 43.49 | 7.83 | | |
| 332.0035 | 10.56 | 194.26 | 42.49 | 42.45 | 1.70 | | |
| 332.0104 | 12.31 | 184.86 | 44.29 | 44.21 | 2.68 | | |
| 332.0174 | 12.07 | 182.66 | 47.50 | 47.27 | 4.67 | | |
| 332.0243 | 12.18 | 182.06 | 49.10 | 48.57 | 7.20 | | |
| 332.0313 | 11.37 | 183.16 | 42.36 | 42.36 | -0.09 | | |
| 332.0382 | 11.71 | 183.56 | 43.42 | 43.40 | 1.02 | | |
| 332.0451 | 12.06 | 181.96 | 41.71 | 41.70 | 0.93 | | |
| 332.0521 | 11.48 | 187.06 | 44.98 | 43.58 | 11.14 | | |
| 332.0590 | 12.06 | 193.76 | 44.29 | 42.79 | 11.45 | | |
| 332.0660 | 10.42 | 200.36 | 44.68 | 41.93 | 15.43 | | |
| 332.0729 | 10.42 | 200.96 | 43.22 | 42.23 | 9.24 | | |
| 332.0799 | 10.18 | 196.06 | 46.10 | 44.52 | 11.98 | | |
| 332.0868 | 8.90 | 194.56 | 43.95 | 43.23 | 7.93 | | |
| 332.0938 | 10.06 | 182.36 | 44.34 | 43.60 | 8.09 | | |
| 332.1007 | 11.10 | 180.06 | 40.75 | 40.47 | 4.76 | | |
| 332.1076 | 10.17 | 183.86 | 41.60 | 41.56 | 1.75 | | |
| 332.1146 | 9.70 | 176.96 | 39.40 | 39.39 | 1.24 | | |
| 332.1215 | 9.24 | 180.46 | 41.95 | 41.87 | 2.54 | | |
| 332.1285 | 9.92 | 183.26 | 42.18 | 42.02 | 3.69 | | |
| 332.1354 | 9.46 | 162.36 | 40.52 | 40.49 | 1.72 | | |
| 332.1424 | 9.57 | 151.86 | 43.39 | 43.15 | 4.62 | | |
| 332.1493 | 9.92 | 137.86 | 38.74 | 38.70 | 1.81 | | |
| 332.1563 | 10.15 | 127.86 | 35.9[illegible] | 35.89 | 1.24 | | |
| 332.1632 | 9.79 | 111.96 | 33.08 | 32.09 | -8.05 | | |
| 332.1701 | 9.56 | 103.46 | 30.42 | 30.32 | -2.50 | | |
| 332.1771 | 9.33 | 105.56 | 31.21 | 30.96 | -3.96 | | |
| 332.1840 | 8.64 | 106.96 | 33.52 | 33.15 | -4.97 | | |
| 332.1910 | 8.75 | 107.76 | 32.04 | 31.75 | -4.27 | | |
| 332.1979 | 9.10 | 122.66 | 29.62 | 29.21 | -4.94 | | |
| 332.2049 | 9.44 | 124.76 | 29.70 | 29.63 | -1.92 | | |
| 332.2118 | 8.86 | 125.86 | 34.21 | 32.81 | -9.70 | | |
| 332.2188 | 8.40 | 126.56 | 31.40 | 29.32 | -11.22 | | |
| 332.2257 | 8.05 | 127.06 | 29.68 | 29.31 | -4.68 | | |
| 332.2326 | 8.17 | 123.66 | 29.79 | 29.39 | -4.86 | | |
| 332.2396 | 8.40 | 121.76 | 29.40 | 28.56 | -6.97 | | |
| 332.2465 | 8.62 | 125.66 | 29.20 | 27.84 | -8.81 | | |
| 332.2535 | 8.28 | 126.06 | 31.72 | 30.10 | -10.01 | | |
| 332.2604 | 8.28 | 132.46 | 26.17 | 24.61 | -8.91 | | |
| 332.2674 | 8.05 | 134.86 | 29.07 | 28.55 | -5.45 | | |

5.5m Open Boat, Std.Conf.Run 60

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 332.2743 | 7.02 | 137.86 | 27.93 | 27.04 | -6.98 | | |
| 332.2813 | 7.48 | 135.26 | 23.26 | 22.21 | -6.90 | | |
| 332.2882 | 7.25 | 138.36 | 27.99 | 27.75 | -3.61 | | |
| 332.2951 | 6.23 | 140.86 | 22.28 | 21.34 | -6.41 | | |
| 332.3021 | 7.36 | 141.36 | 26.60 | 25.06 | -8.94 | | |
| 332.3090 | 6.12 | 137.86 | 23.62 | 22.03 | -8.51 | | |
| 332.3160 | 6.34 | 140.46 | 23.64 | 21.62 | -9.56 | | |
| 332.3229 | 5.45 | 143.16 | 22.40 | 19.58 | -10.89 | | |
| 332.3299 | 6.45 | 143.96 | 17.37 | 13.77 | -10.58 | | |
| 332.3368 | 5.01 | 148.66 | 21.65 | 19.88 | -8.57 | | |
| 332.3438 | 6.12 | 148.36 | 19.25 | 16.40 | -10.09 | | |
| 332.3507 | 5.34 | 143.36 | 17.69 | 16.19 | -7.12 | | |
| 332.3576 | 4.56 | 146.76 | 20.79 | 19.50 | -7.21 | | |
| 332.3646 | 6.34 | 139.66 | 19.29 | 18.42 | -5.72 | | |
| 332.3715 | 4.79 | 143.26 | 18.87 | 18.07 | -5.43 | | |
| 332.3785 | 4.89 | 143.46 | 19.21 | 18.54 | -5.01 | | |
| 332.3854 | 5.78 | 142.56 | 17.71 | 17.70 | -0.58 | | |
| 332.3924 | 4.13 | 147.26 | 20.43 | 20.43 | 0.18 | | |
| 332.3993 | 5.56 | 152.26 | 19.80 | 19.77 | 1.20 | | |
| 332.4063 | 4.45 | 148.26 | 20.62 | 20.58 | 1.33 | | |
| 332.4132 | 4.24 | 142.96 | 22.65 | 22.52 | 2.39 | | |
| 332.4201 | 5.78 | 145.36 | 18.08 | 18.07 | -0.42 | | |
| 332.4271 | 5.23 | 151.06 | 21.74 | 21.72 | -0.79 | | |
| 332.4340 | 3.80 | 156.36 | 16.71 | 16.53 | -2.39 | | |
| 332.4410 | 5.23 | 157.76 | 19.95 | 19.91 | -1.14 | | |
| 332.4479 | 3.91 | 155.46 | 15.54 | 15.38 | -2.24 | | |
| 332.4549 | 3.69 | 156.76 | 14.98 | 14.72 | -2.75 | | |
| 332.4618 | 3.15 | 158.46 | 12.45 | 11.69 | -4.29 | | |
| 332.4688 | 3.04 | 158.26 | 13.75 | 13.13 | -4.10 | | |
| 332.4757 | 3.04 | 162.96 | 13.21 | 13.06 | -1.94 | | |
| 332.4826 | 2.94 | 158.56 | 13.29 | 12.37 | -4.86 | | |
| 332.4896 | 2.41 | 173.96 | 11.22 | 10.76 | -3.17 | | |
| 332.4965 | 2.51 | 174.76 | 13.21 | 12.94 | -2.65 | | |
| 332.5035 | 2.30 | 186.36 | 11.03 | 10.16 | -4.30 | | |
| 332.5104 | 2.41 | 181.66 | 11.00 | 10.70 | -2.54 | | |
| 332.5174 | 2.19 | 182.86 | 10.32 | 10.10 | -2.14 | | |
| 332.5243 | 2.20 | 183.06 | 10.21 | 10.02 | -1.96 | | |
| 332.5313 | 2.20 | 212.86 | 7.38 | 7.28 | -1.19 | | |
| 332.5382 | 2.20 | 212.66 | 8.20 | 8.05 | 1.55 | | |
| 332.5451 | 2.20 | 284.46 | 5.65 | 5.65 | 0.06 | | |
| 332.5521 | 2.20 | 291.26 | 7.21 | 6.44 | 3.24 | | |
| 332.5590 | 2.20 | 333.86 | 5.99 | 3.91 | 4.54 | | |
| 332.5660 | 2.20 | 323.46 | 8.22 | 2.47 | 7.84 | | |
| 332.5729 | 2.30 | 344.66 | 9.81 | -3.55 | 9.14 | | |
| 332.5799 | 2.41 | 309.96 | 10.41 | -3.79 | 9.69 | | |
| 332.5868 | 2.73 | 341.26 | 17.53 | -2.13 | 17.40 | | |
| 332.5938 | 3.05 | 338.06 | 16.26 | -5.19 | 15.41 | | |
| 332.6007 | 3.60 | 356.56 | 17.85 | -4.28 | 17.33 | | |

5.5m Open Boat, Std.Conf.Run 60

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 332.6076 | 3.70 | 335.36 | 19.07 | -11.28 | 15.37 | | |
| 332.6146 | 4.14 | 338.66 | 21.11 | -16.02 | 13.74 | | |
| 332.6215 | 4.36 | 345.16 | 22.53 | -14.50 | 17.25 | | |
| 332.6285 | 4.47 | 346.56 | 23.29 | -16.98 | 15.94 | | |
| 332.6354 | 4.58 | 344.56 | 24.80 | -14.62 | 20.03 | | |
| 332.6424 | 4.58 | 352.56 | 30.42 | -18.24 | 24.34 | | |
| 332.6493 | 5.03 | 356.56 | 30.86 | -23.68 | 19.79 | | |
| 332.6563 | 5.14 | 352.26 | 30.17 | -23.93 | 18.37 | | |
| 332.6632 | 5.59 | 357.16 | 26.40 | -16.75 | 20.41 | | |
| 332.6701 | 5.81 | 358.66 | 24.35 | -16.52 | 17.89 | | |
| 332.6771 | 6.26 | 355.96 | 27.56 | -20.62 | 18.28 | | |
| 332.6840 | 6.83 | 358.86 | 34.65 | -24.60 | 24.41 | | |
| 332.6910 | 7.18 | 3.16 | 34.93 | -24.10 | 25.28 | | |
| 332.6979 | 7.52 | 7.06 | 30.51 | -22.94 | 20.11 | | |
| 332.7049 | 7.87 | 5.26 | 30.23 | -19.94 | 22.73 | | |
| 332.7118 | 7.18 | 4.46 | 29.75 | -20.82 | 21.25 | | |
| 332.7188 | 8.22 | 8.36 | 30.22 | -18.16 | 24.16 | | |
| 332.7257 | 9.03 | 12.16 | 32.69 | -15.22 | 28.93 | | |
| 332.7326 | 9.38 | 23.56 | 34.40 | -13.74 | 31.54 | | |
| 332.7396 | 9.73 | 24.46 | 35.21 | -13.51 | 32.51 | | |
| 332.7465 | 9.73 | 27.86 | 36.48 | -12.34 | 34.33 | | |
| 332.7535 | 9.97 | 22.96 | 36.80 | -15.07 | 33.58 | | |
| 332.7604 | 9.74 | 16.76 | 39.72 | -26.28 | 29.78 | | |
| 332.7674 | 9.98 | 12.96 | 37.75 | -22.40 | 30.38 | | |
| 332.7743 | 10.44 | 15.06 | 40.58 | -25.85 | 31.28 | | |
| 332.7813 | 10.10 | 15.76 | 37.34 | -21.40 | 30.60 | | |
| 332.7882 | 10.80 | 18.56 | 38.71 | -24.11 | 30.29 | | |
| 332.7951 | 10.81 | 18.66 | 40.74 | -29.03 | 28.58 | | |
| 332.8021 | 11.16 | 15.66 | 43.05 | -30.93 | 29.94 | | |
| 332.8090 | 12.45 | 16.76 | 47.50 | -31.44 | 35.60 | | |
| 332.8160 | 12.69 | 19.96 | 48.52 | -31.55 | 36.86 | | |
| 332.8229 | 13.16 | 19.36 | 48.86 | -36.44 | 32.55 | | |
| 332.8299 | 13.75 | 20.06 | 50.47 | -35.64 | 35.74 | | |
| 332.8368 | 13.99 | 21.46 | 48.06 | -33.85 | 34.12 | | |
| 332.8438 | 14.34 | 19.26 | 52.71 | -41.45 | 32.55 | | |
| 332.8507 | 14.46 | 17.86 | 53.85 | -41.54 | 34.26 | | |
| 332.8576 | 14.34 | 18.86 | 54.48 | -43.79 | 32.40 | | |
| 332.8646 | 14.11 | 18.86 | 56.26 | -43.34 | 35.87 | | |
| 332.8715 | 15.28 | 17.66 | 56.19 | -47.01 | 30.78 | | |
| 332.8785 | 14.93 | 16.46 | 58.08 | -48.57 | 31.85 | | |
| 332.8854 | 15.52 | 16.76 | 56.19 | -47.40 | 30.18 | | |
| 332.8924 | 15.76 | 17.86 | 59.16 | -51.39 | 29.31 | | |
| 332.8993 | 15.88 | 15.96 | 56.14 | -47.50 | 29.91 | | |
| 332.9063 | 15.06 | 17.56 | 57.69 | -47.05 | 33.38 | | |
| 332.9132 | 15.42 | 21.86 | 59.03 | -50.32 | 30.87 | | |
| 332.9201 | 15.53 | 18.76 | 55.73 | -47.94 | 28.41 | | |
| 332.9271 | 16.00 | 20.66 | 59.76 | -51.81 | 29.78 | | |
| 332.9340 | 16.12 | 21.96 | 56.53 | -47.95 | 29.94 | | |

5.5m Open Boat, Std.Conf.Run 60

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 332.9410 | 16.25 | 22.36 | 47.32 | -34.28 | 32.62 | | |

Life Raft "J",Std.Conf.,Run 63

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 330.6215 | 7.74 | 288.66 | 17.84 | -16.89 | 5.73 | 0.02 | 17.84 |
| 330.6285 | 8.43 | 283.06 | 18.25 | -17.13 | 6.28 | 2.25 | 18.11 |
| 330.6354 | 8.43 | 284.16 | 17.42 | -16.55 | 5.44 | 1.23 | 17.38 |
| 330.6424 | 8.32 | 281.66 | 16.90 | -16.23 | 4.71 | 1.33 | 16.85 |
| 330.6493 | 7.63 | 281.76 | 17.40 | -16.89 | 4.20 | 0.68 | 17.39 |
| 330.6563 | 6.72 | 282.16 | 17.13 | -15.67 | 6.92 | 3.46 | 16.77 |
| 330.6632 | 6.95 | 283.36 | 16.18 | -14.49 | 7.21 | 3.67 | 15.76 |
| 330.6701 | 7.20 | 290.86 | 16.97 | -15.69 | 6.47 | 0.46 | 16.97 |
| 330.6771 | 7.20 | 290.66 | 17.71 | -16.81 | 5.54 | -0.74 | 17.69 |
| 330.6840 | 7.55 | 286.06 | 16.41 | -15.16 | 6.26 | 1.83 | 16.31 |
| 330.6910 | 7.55 | 286.96 | 15.43 | -14.09 | 6.30 | 1.91 | 15.31 |
| 330.6979 | 7.44 | 287.66 | 15.70 | -14.66 | 5.61 | 0.90 | 15.67 |
| 330.7049 | 7.56 | 286.26 | 15.58 | -14.17 | 6.48 | 2.25 | 15.42 |
| 330.7118 | 7.46 | 285.66 | 15.14 | -14.24 | 5.14 | 1.11 | 15.10 |
| 330.7188 | 7.81 | 287.66 | 14.99 | -14.06 | 5.22 | 0.71 | 14.98 |
| 330.7257 | 7.60 | 283.76 | 15.14 | -14.24 | 5.14 | 1.61 | 15.05 |
| 330.7326 | 7.26 | 278.96 | 15.28 | -14.01 | 6.11 | 3.86 | 14.79 |
| 330.7396 | 7.16 | 280.86 | 16.01 | -15.24 | 4.92 | 1.97 | 15.89 |
| 330.7465 | 7.40 | 283.16 | 15.77 | -14.04 | 7.19 | 3.81 | 15.31 |
| 330.7535 | 7.29 | 284.76 | 16.00 | -15.13 | 5.19 | 1.16 | 15.95 |
| 330.7604 | 6.95 | 280.26 | 15.49 | -14.92 | 4.19 | 1.47 | 15.42 |
| 330.7674 | 6.84 | 282.56 | 16.60 | -15.87 | 4.87 | 1.30 | 16.54 |
| 330.7743 | 7.31 | 282.96 | 17.41 | -16.45 | 5.70 | 1.87 | 17.31 |
| 330.7813 | 7.66 | 281.36 | 17.59 | -16.84 | 5.10 | 1.68 | 17.51 |
| 330.7882 | 7.79 | 284.46 | 17.41 | -15.93 | 7.02 | 2.82 | 17.18 |
| 330.7951 | 8.36 | 286.46 | 18.01 | -16.25 | 7.75 | 2.83 | 17.78 |
| 330.8021 | 8.85 | 288.96 | 17.75 | -15.88 | 7.91 | 2.33 | 17.59 |
| 330.8090 | 7.94 | 285.66 | 17.42 | -16.55 | 5.44 | 0.77 | 17.41 |
| 330.8160 | 8.30 | 287.66 | 16.98 | -16.00 | 5.68 | 0.56 | 16.97 |
| 330.8229 | 7.98 | 285.36 | 15.86 | -15.05 | 5.00 | 0.84 | 15.84 |
| 330.8299 | 8.31 | 285.46 | 15.85 | -14.53 | 6.32 | 2.22 | 15.69 |
| 330.8368 | 8.41 | 283.66 | 17.26 | -16.26 | 5.78 | 1.78 | 17.17 |
| 330.8438 | 8.86 | 285.26 | 18.68 | -17.17 | 7.35 | 2.58 | 18.50 |
| 330.8507 | 8.85 | 285.66 | 18.25 | -16.82 | 7.07 | 2.27 | 18.11 |
| 330.8576 | 8.86 | 287.06 | 20.04 | -17.29 | 10.14 | 4.62 | 19.50 |
| 330.8646 | 9.08 | 291.66 | 21.34 | -17.25 | 12.55 | 5.30 | 20.67 |
| 330.8715 | 9.21 | 294.96 | 22.33 | -18.12 | 13.05 | 4.18 | 21.93 |
| 330.8785 | 9.89 | 297.66 | 21.39 | -16.00 | 14.19 | 5.14 | 20.76 |
| 330.8854 | 10.12 | 300.66 | 20.93 | -16.23 | 13.22 | 3.09 | 20.70 |
| 330.8924 | 9.55 | 302.46 | 19.72 | -14.24 | 13.65 | 3.88 | 19.34 |
| 330.8993 | 9.55 | 306.46 | 19.23 | -12.95 | 14.21 | 3.73 | 18.86 |
| 330.9063 | 9.54 | 310.96 | 19.83 | -14.13 | 13.91 | 1.24 | 19.79 |
| 330.9132 | 9.32 | 309.96 | 20.81 | -13.78 | 15.59 | 3.11 | 20.58 |
| 330.9201 | 9.21 | 316.96 | 18.63 | -11.59 | 14.58 | 1.48 | 18.57 |
| 330.9271 | 9.32 | 317.76 | 18.31 | -13.02 | 12.87 | -0.99 | 18.28 |
| 330.9340 | 8.98 | 316.76 | 19.62 | -13.58 | 14.15 | -0.20 | 19.62 |
| 330.9410 | 8.98 | 312.36 | 19.24 | -14.47 | 12.68 | -0.38 | 19.23 |
| 330.9479 | 9.66 | 304.66 | 19.60 | -14.63 | 13.04 | 2.41 | 19.45 |

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 330.9549 | 9.54 | 306.06 | 21.47 | -16.76 | 13.42 | 0.99 | 21.45 |
| 330.9618 | 9.43 | 304.96 | 21.39 | -12.89 | 17.07 | 6.60 | 20.35 |
| 330.9688 | 10.12 | 310.66 | 24.48 | -11.58 | 21.57 | 8.82 | 22.84 |
| 330.9757 | 11.38 | 320.66 | 20.82 | -13.31 | 16.02 | -0.14 | 20.82 |
| 330.9826 | 9.14 | 316.16 | 19.43 | -14.26 | 13.20 | -1.14 | 19.40 |
| 330.9896 | 9.02 | 307.66 | 18.72 | -13.65 | 12.81 | 1.80 | 18.64 |
| 330.9965 | 8.91 | 303.66 | 20.69 | -13.41 | 15.75 | 5.68 | 19.89 |
| 331.0035 | 10.95 | 318.36 | 21.14 | -11.79 | 17.55 | 2.85 | 20.95 |
| 331.0104 | 9.33 | 316.36 | 19.69 | -13.77 | 14.07 | -0.25 | 19.68 |
| 331.0174 | 9.85 | 307.56 | 20.81 | -13.78 | 15.59 | 3.97 | 20.43 |
| 331.0243 | 9.59 | 304.26 | 20.06 | -13.93 | 14.44 | 4.09 | 19.64 |
| 331.0313 | 10.15 | 306.86 | 23.38 | -14.53 | 18.32 | 5.95 | 22.61 |
| 331.0382 | 10.72 | 312.46 | 24.52 | -11.95 | 21.41 | 7.73 | 23.27 |
| 331.0451 | 11.41 | 318.46 | 24.07 | -11.24 | 21.28 | 5.70 | 23.38 |
| 331.0521 | 11.54 | 321.16 | 25.42 | -11.06 | 22.89 | 5.74 | 24.76 |
| 331.0590 | 12.81 | 322.96 | 26.00 | -10.75 | 23.68 | 5.68 | 25.37 |
| 331.0660 | 13.16 | 322.76 | 26.03 | -11.49 | 23.36 | 4.99 | 25.54 |
| 331.0729 | 13.15 | 327.06 | 27.21 | -10.32 | 25.18 | 5.03 | 26.74 |
| 331.0799 | 13.26 | 323.76 | 27.76 | -8.28 | 26.50 | 8.99 | 26.27 |
| 331.0868 | 12.92 | 328.26 | 26.42 | -7.35 | 25.38 | 7.10 | 25.45 |
| 331.0938 | 12.93 | 328.66 | 24.48 | -7.91 | 23.17 | 5.29 | 23.90 |
| 331.1007 | 12.70 | 330.66 | 24.21 | -10.22 | 21.95 | 1.85 | 24.14 |
| 331.1076 | 12.25 | 330.96 | 26.65 | -9.16 | 25.02 | 4.14 | 26.32 |
| 331.1146 | 12.72 | 331.46 | 27.64 | -7.65 | 26.56 | 5.97 | 26.98 |
| 331.1215 | 12.71 | 327.56 | 27.47 | -9.11 | 25.92 | 6.21 | 26.76 |
| 331.1285 | 13.40 | 328.66 | 29.06 | -9.93 | 27.30 | 5.72 | 28.49 |
| 331.1354 | 14.45 | 331.06 | 29.75 | -9.07 | 28.33 | 5.77 | 29.19 |
| 331.1424 | 15.02 | 330.66 | 29.27 | -9.83 | 27.57 | 4.94 | 28.85 |
| 331.1493 | 15.02 | 330.36 | 29.42 | -10.64 | 27.43 | 4.32 | 29.11 |
| 331.1563 | 15.37 | 330.26 | 30.27 | -10.23 | 28.48 | 5.25 | 29.81 |
| 331.1632 | 15.83 | 331.36 | 32.60 | -13.02 | 29.89 | 2.90 | 32.47 |
| 331.1701 | 15.26 | 331.86 | 30.81 | -11.57 | 28.56 | 3.27 | 30.64 |
| 331.1771 | 15.84 | 330.56 | 31.26 | -10.63 | 29.40 | 5.20 | 30.83 |
| 331.1840 | 15.50 | 330.16 | 33.73 | -10.67 | 32.00 | 6.67 | 33.07 |
| 331.1910 | 15.50 | 329.46 | 33.81 | -12.77 | 31.31 | 4.91 | 33.45 |
| 331.1979 | 16.20 | 330.66 | 34.10 | -8.11 | 33.12 | 9.17 | 32.84 |
| 331.2049 | 15.61 | 330.86 | 31.83 | -7.78 | 30.86 | 8.24 | 30.74 |
| 331.2118 | 15.83 | 330.76 | 32.58 | -9.83 | 31.06 | 6.60 | 31.90 |
| 331.2188 | 16.41 | 331.16 | 29.99 | -8.79 | 28.68 | 6.14 | 29.36 |
| 331.2257 | 16.41 | 332.66 | 32.42 | -9.38 | 31.04 | 5.93 | 31.88 |
| 331.2326 | 16.30 | 332.06 | 31.76 | -8.14 | 30.70 | 7.19 | 30.94 |
| 331.2396 | 16.66 | 331.36 | 33.12 | -10.62 | 31.37 | 5.72 | 32.62 |
| 331.2465 | 16.54 | 331.36 | 32.60 | -13.02 | 29.89 | 2.90 | 32.47 |
| 331.2535 | 17.12 | 327.46 | 29.40 | -11.56 | 27.03 | 4.80 | 29.01 |
| 331.2604 | 16.66 | 329.96 | 27.72 | -8.64 | 26.34 | 5.71 | 27.13 |
| 331.2674 | 20.44 | 339.36 | 37.85 | -13.27 | 35.45 | -0.11 | 37.85 |
| 331.2743 | 17.21 | 333.86 | 33.15 | -8.70 | 31.99 | 6.28 | 32.55 |
| 331.2813 | 16.82 | 332.16 | 34.68 | -9.71 | 33.29 | 6.97 | 33.97 |

Life Raft "J",Std.Conf.,Run 63

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 331.2882 | 17.04 | 334.96 | 34.30 | -11.28 | 32.39 | 3.49 | 34.12 |
| 331.2951 | 16.91 | 332.36 | 34.47 | -11.72 | 32.41 | 4.65 | 34.15 |
| 331.3021 | 17.15 | 334.46 | 34.77 | -10.70 | 33.08 | 4.61 | 34.46 |
| 331.3090 | 17.97 | 335.36 | 35.08 | -8.50 | 34.04 | 6.46 | 34.48 |
| 331.3160 | 17.63 | 335.36 | 36.95 | -7.68 | 36.14 | 8.09 | 36.05 |
| 331.3229 | 18.21 | 335.86 | 34.53 | -8.08 | 33.57 | 6.36 | 33.94 |
| 331.3299 | 18.21 | 337.16 | 40.45 | -10.48 | 39.07 | 5.51 | 40.07 |
| 331.3368 | 17.27 | 338.06 | 36.18 | -9.53 | 34.90 | 4.20 | 35.93 |
| 331.3438 | 17.85 | 337.66 | 37.59 | -11.46 | 35.80 | 3.02 | 37.47 |
| 331.3507 | 17.03 | 337.26 | 34.01 | -10.02 | 32.50 | 3.33 | 33.85 |
| 331.3576 | 18.20 | 336.06 | 37.22 | -11.11 | 35.52 | 4.26 | 36.97 |
| 331.3646 | 18.32 | 335.36 | 35.23 | -12.78 | 32.83 | 2.08 | 35.17 |
| 331.3715 | 19.02 | 336.76 | 37.14 | -7.76 | 36.33 | 7.21 | 36.44 |
| 331.3785 | 18.32 | 336.86 | 36.26 | -12.63 | 33.99 | 1.75 | 36.21 |
| 331.3854 | 18.44 | 338.66 | 38.92 | -10.84 | 37.38 | 3.51 | 38.76 |
| 331.3924 | 18.68 | 337.76 | 33.61 | -7.32 | 32.81 | 5.65 | 33.14 |
| 331.3993 | 19.39 | 338.56 | 34.49 | -5.46 | 34.05 | 7.37 | 33.69 |
| 331.4063 | 19.15 | 339.16 | 32.02 | -13.70 | 28.94 | -2.51 | 31.92 |
| 331.4132 | 19.50 | 338.46 | 34.28 | -9.55 | 32.93 | 3.21 | 34.13 |
| 331.4201 | 19.61 | 338.36 | 33.00 | -12.82 | 30.41 | -0.69 | 33.00 |
| 331.4271 | 18.56 | 338.26 | 33.24 | -9.52 | 31.85 | 2.96 | 33.11 |
| 331.4340 | 19.15 | 337.36 | 33.80 | -8.58 | 32.70 | 4.67 | 33.48 |
| 331.4410 | 18.80 | 337.46 | 33.21 | -8.34 | 32.15 | 4.63 | 32.89 |
| 331.4479 | 19.03 | 339.36 | 33.04 | -6.08 | 32.48 | 5.76 | 32.53 |
| 331.4549 | 18.68 | 342.56 | 32.79 | -5.37 | 32.35 | 4.58 | 32.47 |
| 331.4618 | 18.08 | 345.16 | 32.80 | -0.33 | 32.80 | 8.08 | 31.79 |
| 331.4688 | 18.08 | 348.66 | 32.70 | -0.07 | 32.70 | 6.37 | 32.07 |
| 331.4757 | 17.49 | 352.46 | 34.26 | 1.89 | 34.20 | 6.37 | 33.66 |
| 331.4826 | 17.84 | 359.36 | 31.51 | 2.91 | 31.37 | 3.26 | 31.34 |
| 331.4896 | 17.12 | 4.06 | 31.73 | 3.72 | 31.51 | 1.48 | 31.69 |
| 331.4965 | 17.10 | 4.06 | 30.86 | 1.18 | 30.84 | -1.00 | 30.84 |
| 331.5035 | 16.15 | 22.66 | 28.47 | 4.08 | 28.18 | -7.08 | 27.58 |
| | Wind Direction | | | | | Crosswind & | Downwind |
| | | Fails | | | | below are | Invalid |
| 331.5104 | 13.80 | 75.46 | 32.74 | 1.90 | 32.68 | | |
| 331.5174 | 22.16 | 77.66 | 32.25 | 4.64 | 31.91 | | |
| 331.5243 | 20.73 | 75.76 | 32.57 | 5.19 | 32.15 | | |
| 331.5313 | 20.01 | 66.06 | 33.29 | 0.77 | 33.28 | | |
| 331.5382 | 20.24 | 60.76 | 34.84 | 6.46 | 34.23 | | |
| 331.5451 | 19.52 | 64.36 | 34.46 | 3.15 | 34.32 | | |
| 331.5521 | 20.12 | 62.96 | 34.57 | 7.07 | 33.84 | | |
| 331.5590 | 19.41 | 64.16 | 36.09 | 3.77 | 35.90 | | |
| 331.5660 | 19.64 | 63.26 | 35.33 | 4.36 | 35.06 | | |
| 331.5729 | 18.93 | 65.86 | 37.36 | 8.10 | 36.47 | | |
| 331.5799 | 18.81 | 69.36 | 33.55 | 4.26 | 33.27 | | |
| 331.5868 | 19.02 | 73.76 | 29.90 | 9.20 | 28.44 | | |
| 331.5938 | 18.19 | 76.76 | 33.65 | 9.50 | 32.28 | | |
| 331.6007 | 18.20 | 74.56 | 32.83 | 13.05 | 30.12 | | |

Life Raft "J",Std.Conf.,Run 63

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 331.6076 | 17.60 | 76.86 | 29.42 | 10.23 | 27.58 | | |
| 331.6146 | 17.95 | 77.66 | 30.83 | 11.54 | 28.59 | | |
| 331.6215 | 17.59 | 77.26 | 31.22 | 13.75 | 28.03 | | |
| 331.6285 | 17.35 | 82.26 | 27.64 | 13.19 | 24.29 | | |
| 331.6354 | 16.76 | 84.26 | 27.76 | 16.75 | 22.13 | | |
| 331.6424 | 16.87 | 86.86 | 29.79 | 15.84 | 25.23 | | |
| 331.6493 | 16.05 | 88.96 | 24.28 | 10.82 | 21.73 | | |
| 331.6563 | 15.81 | 93.66 | 22.86 | 12.65 | 19.04 | | |
| 331.6632 | 15.23 | 94.16 | 22.30 | 15.11 | 16.40 | | |
| 331.6701 | 14.06 | 98.86 | 21.28 | 18.72 | 10.12 | | |
| 331.6771 | 14.19 | 106.36 | 20.55 | 17.00 | 11.55 | | |
| 331.6840 | 14.07 | 108.76 | 23.63 | 22.11 | 8.33 | | |
| 331.6910 | 12.57 | 113.26 | 23.80 | 21.90 | 9.32 | | |
| 331.6979 | 13.38 | 117.16 | 24.81 | 22.97 | 9.36 | | |
| 331.7049 | 12.45 | 123.36 | 22.15 | 21.21 | 6.40 | | |
| 331.7118 | 12.90 | 128.16 | 23.85 | 23.29 | 5.13 | | |
| 331.7188 | 13.24 | 131.96 | 19.83 | 19.17 | 5.08 | | |
| 331.7257 | 13.82 | 137.66 | 17.82 | 17.25 | 4.46 | | |
| 331.7326 | 13.82 | 137.66 | 20.59 | 19.82 | 5.58 | | |
| 331.7396 | 13.00 | 138.86 | 20.23 | 19.97 | 3.25 | | |
| 331.7465 | 12.17 | 141.26 | 23.97 | 23.31 | 5.58 | | |
| 331.7535 | 12.99 | 140.46 | 21.49 | 21.23 | 3.36 | | |
| 331.7604 | 13.70 | 142.36 | 21.61 | 20.82 | 5.80 | | |
| 331.7674 | 13.11 | 145.06 | 18.79 | 18.39 | 3.87 | | |
| 331.7743 | 13.10 | 148.56 | 16.80 | 16.26 | 4.25 | | |
| 331.7813 | 13.44 | 148.46 | 18.28 | 17.78 | 4.26 | | |
| 331.7882 | 13.68 | 149.06 | 21.32 | 21.18 | 2.47 | | |
| 331.7951 | 13.56 | 151.86 | 19.07 | 18.73 | 3.58 | | |
| 331.8021 | 13.57 | 156.76 | 20.49 | 20.42 | 1.70 | | |
| 331.8090 | 12.86 | 160.16 | 21.93 | 21.54 | 4.15 | | |
| 331.8160 | 12.63 | 158.86 | 22.53 | 22.36 | 2.76 | | |
| 331.8229 | 12.28 | 159.66 | 21.67 | 21.67 | -0.16 | | |
| 331.8299 | 13.09 | 160.36 | 19.53 | 19.04 | 4.37 | | |
| 331.8368 | 14.61 | 161.96 | 22.66 | 22.46 | 3.02 | | |
| 331.8438 | 13.43 | 165.46 | 22.83 | 22.82 | -0.31 | | |
| 331.8507 | 13.32 | 166.96 | 23.35 | 23.30 | -1.41 | | |
| 331.8576 | 12.96 | 171.36 | 23.43 | 23.41 | -1.15 | | |
| 331.8646 | 13.08 | 172.56 | 22.80 | 22.45 | -3.96 | | |
| 331.8715 | 13.78 | 172.26 | 22.09 | 21.87 | -3.12 | | |
| 331.8785 | 14.24 | 173.86 | 20.08 | 19.80 | -3.37 | | |
| 331.8854 | 14.24 | 173.46 | 23.88 | 23.85 | -1.17 | | |
| 331.8924 | 13.29 | 179.76 | 23.94 | 23.76 | -2.96 | | |
| 331.8993 | 12.82 | 180.26 | 21.81 | 21.35 | -4.44 | | |
| 331.9063 | 11.88 | 184.76 | 23.33 | 21.77 | -8.40 | | |
| 331.9132 | 12.12 | 183.16 | 20.40 | 19.37 | -6.40 | | |
| 331.9201 | 13.40 | 183.66 | 21.56 | 20.96 | -5.05 | | |
| 331.9271 | 12.70 | 187.46 | 22.03 | 21.77 | -3.39 | | |
| 331.9340 | 13.16 | 188.76 | 22.38 | 22.38 | -0.28 | | |

Life Raft "J",Std.Conf.,Run 63

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 331.9410 | 12.34 | 185.86 | 24.53 | 23.44 | -7.24 | | |
| 331.9479 | 12.69 | 183.76 | 22.23 | 21.03 | -7.20 | | |
| 331.9549 | 11.52 | 183.86 | 21.28 | 20.36 | -6.18 | | |
| 331.9618 | 11.98 | 188.66 | 23.43 | 20.94 | -10.51 | | |
| 331.9688 | 12.45 | 192.56 | 20.44 | 19.57 | -5.87 | | |
| 331.9757 | 12.32 | 192.76 | 20.25 | 19.98 | -3.29 | | |
| 331.9826 | 11.50 | 194.56 | 20.04 | 19.57 | -4.35 | | |
| 331.9896 | 10.68 | 199.46 | 20.51 | 19.24 | -7.11 | | |
| 331.9965 | 10.33 | 199.46 | 21.81 | 20.68 | -6.91 | | |
| 332.0035 | 10.56 | 194.26 | 21.80 | 20.58 | -7.18 | | |
| 332.0104 | 12.31 | 184.86 | 21.43 | 19.20 | -9.52 | | |
| 332.0174 | 12.07 | 182.66 | 20.90 | 18.57 | -9.58 | | |
| 332.0243 | 12.18 | 182.06 | 18.10 | 16.85 | -6.62 | | |
| 332.0313 | 11.37 | 183.16 | 18.64 | 15.58 | -10.23 | | |
| 332.0382 | 11.71 | 183.56 | 18.12 | 15.84 | -8.81 | | |
| 332.0451 | 12.06 | 181.96 | 20.96 | 19.07 | -8.71 | | |
| 332.0521 | 11.48 | 187.06 | 18.28 | 17.78 | -4.25 | | |
| 332.0590 | 12.06 | 193.76 | 19.59 | 18.78 | -5.56 | | |
| 332.0660 | 10.42 | 200.36 | 18.98 | 18.05 | -5.88 | | |
| 332.0729 | 10.42 | 200.96 | 18.88 | 18.41 | -4.20 | | |
| 332.0799 | 10.18 | 196.06 | 17.62 | 16.94 | -4.83 | | |
| 332.0868 | 8.90 | 194.56 | 18.95 | 17.74 | -6.67 | | |
| 332.0938 | 10.06 | 182.36 | 18.98 | 17.22 | -7.98 | | |
| 332.1007 | 11.10 | 180.06 | 19.52 | 17.15 | -9.32 | | |
| 332.1076 | 10.17 | 183.86 | 19.28 | 16.79 | -9.48 | | |
| 332.1146 | 9.70 | 176.96 | 19.72 | 17.73 | -8.64 | | |
| 332.1215 | 9.24 | 180.46 | 21.69 | 18.48 | -11.36 | | |
| 332.1285 | 9.92 | 183.26 | 17.20 | 14.76 | -8.84 | | |
| 332.1354 | 9.46 | 162.36 | 19.40 | 16.97 | -9.40 | | |
| 332.1424 | 9.57 | 151.86 | 19.44 | 16.87 | -9.67 | | |
| 332.1493 | 9.92 | 137.86 | 17.88 | 15.47 | -8.97 | | |
| 332.1563 | 10.15 | 127.86 | 16.98 | 14.39 | -9.00 | | |
| 332.1632 | 9.79 | 111.96 | 16.43 | 14.96 | -6.79 | | |
| 332.1701 | 9.56 | 103.46 | 17.13 | 15.67 | -6.92 | | |
| 332.1771 | 9.33 | 105.56 | 15.98 | 14.92 | -5.71 | | |
| 332.1840 | 8.64 | 106.96 | 18.67 | 17.37 | -6.83 | | |
| 332.1910 | 8.75 | 107.76 | 17.28 | 15.05 | -8.50 | | |
| 332.1979 | 9.10 | 122.66 | 16.55 | 15.24 | -6.45 | | |
| 332.2049 | 9.44 | 124.76 | 16.00 | 14.61 | -6.50 | | |
| 332.2118 | 8.86 | 125.86 | 14.68 | 12.88 | -7.04 | | |
| 332.2188 | 8.40 | 126.56 | 14.48 | 12.41 | -7.46 | | |
| 332.2257 | 8.05 | 127.06 | 13.84 | 12.09 | -6.73 | | |
| 332.2326 | 8.17 | 123.66 | 15.56 | 14.37 | -5.95 | | |
| 332.2396 | 8.40 | 121.76 | 13.72 | 12.72 | -5.15 | | |
| 332.2465 | 8.62 | 125.66 | 15.00 | 14.16 | -4.96 | | |
| 332.2535 | 8.28 | 126.06 | 14.88 | 13.46 | -6.35 | | |
| 332.2604 | 8.28 | 132.46 | 14.78 | 13.17 | -6.70 | | |
| 332.2674 | 8.05 | 134.86 | 14.32 | 12.93 | -6.15 | | |

Life Raft "J",Std.Conf.,Run 63

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 332.2743 | 7.02 | 137.86 | 14.26 | 12.05 | -7.62 | | |
| 332.2813 | 7.48 | 135.26 | 11.65 | 9.89 | -6.16 | | |
| 332.2882 | 7.25 | 138.36 | 12.59 | 11.87 | -4.21 | | |
| 332.2951 | 6.23 | 140.86 | 13.00 | 11.31 | -6.42 | | |
| 332.3021 | 7.36 | 141.36 | 12.40 | 10.88 | -5.95 | | |
| 332.3090 | 6.12 | 137.86 | 13.10 | 10.71 | -7.55 | | |
| 332.3160 | 6.34 | 140.46 | 12.47 | 11.27 | -5.34 | | |
| 332.3229 | 5.45 | 143.16 | 12.63 | 11.35 | -5.53 | | |
| 332.3299 | 6.45 | 143.96 | 12.09 | 10.72 | -5.58 | | |
| 332.3368 | 5.01 | 148.66 | 10.76 | 9.20 | -5.59 | | |
| 332.3438 | 6.12 | 148.36 | 11.53 | 10.20 | -5.37 | | |
| 332.3507 | 5.34 | 143.36 | 11.05 | 10.06 | -4.56 | | |
| 332.3576 | 4.56 | 146.76 | 11.93 | 10.15 | -6.27 | | |
| 332.3646 | 6.34 | 139.66 | 10.32 | 8.47 | -5.91 | | |
| 332.3715 | 4.79 | 143.26 | 11.54 | 9.70 | -6.24 | | |
| 332.3785 | 4.89 | 143.46 | 10.04 | 8.59 | -5.20 | | |
| 332.3854 | 5.78 | 142.56 | 11.03 | 10.27 | -4.03 | | |
| 332.3924 | 4.13 | 147.26 | 10.75 | 10.00 | -3.93 | | |
| 332.3993 | 5.56 | 152.26 | 11.06 | 10.58 | -3.25 | | |
| 332.4063 | 4.45 | 148.26 | 9.90 | 9.21 | -3.62 | | |
| 332.4132 | 4.24 | 142.96 | 12.47 | 11.89 | -3.76 | | |
| 332.4201 | 5.78 | 145.36 | 11.40 | 11.05 | -2.82 | | |
| 332.4271 | 5.23 | 151.06 | 11.88 | 11.06 | -4.35 | | |
| 332.4340 | 3.80 | 156.36 | 11.84 | 11.49 | -2.85 | | |
| 332.4410 | 5.23 | 157.76 | 12.65 | 12.41 | -2.45 | | |
| 332.4479 | 3.91 | 155.46 | 12.37 | 11.92 | -3.32 | | |
| 332.4549 | 3.69 | 156.76 | 11.65 | 10.38 | -5.29 | | |
| 332.4618 | 3.15 | 158.46 | 11.00 | 10.70 | -2.54 | | |
| 332.4688 | 3.04 | 158.26 | 8.79 | 8.37 | -2.68 | | |
| 332.4757 | 3.04 | 162.96 | 8.22 | 7.84 | -2.47 | | |
| 332.4826 | 2.94 | 158.56 | 9.90 | 9.32 | -3.36 | | |
| 332.4896 | 2.41 | 173.96 | 8.37 | 8.02 | -2.39 | | |
| 332.4965 | 2.51 | 174.76 | 8.77 | 8.06 | -3.47 | | |
| 332.5035 | 2.30 | 186.36 | 8.92 | 8.45 | -2.86 | | |
| 332.5104 | 2.41 | 181.66 | 8.96 | 7.93 | -4.18 | | |
| 332.5174 | 2.19 | 182.86 | 7.36 | 6.74 | -2.95 | | |
| 332.5243 | 2.20 | 183.06 | 7.78 | 7.19 | -2.98 | | |
| 332.5313 | 2.20 | 212.86 | 6.97 | 6.71 | -1.88 | | |
| 332.5382 | 2.20 | 212.66 | 6.66 | 6.57 | -1.06 | | |
| 332.5451 | 2.20 | 284.46 | 6.25 | 6.00 | -1.75 | | |
| 332.5521 | 2.20 | 291.26 | 6.66 | 6.34 | -2.04 | | |
| 332.5590 | 2.20 | 333.86 | 4.72 | 4.60 | -1.05 | | |
| 332.5660 | 2.20 | 323.46 | 5.28 | 5.26 | -0.55 | | |
| 332.5729 | 2.30 | 344.66 | 4.67 | 4.54 | 1.10 | | |
| 332.5799 | 2.41 | 309.96 | 4.75 | 4.70 | 0.74 | | |
| 332.5868 | 2.73 | 341.26 | 5.00 | 4.66 | 1.81 | | |
| 332.5938 | 3.05 | 338.06 | 4.20 | 3.85 | 1.68 | | |
| 332.6007 | 3.60 | 356.56 | 4.71 | 3.82 | 2.75 | | |

Life Raft "J",Std.Conf.,Run 63

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Wind Dir. (Towards) (Deg True) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) | Crosswind Leeway (cm/s) | Downwind Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 332.6076 | 3.70 | 335.36 | 6.68 | 3.09 | 5.93 | | |
| 332.6146 | 4.14 | 338.66 | 8.79 | 3.73 | 7.95 | | |
| 332.6215 | 4.36 | 345.16 | 8.64 | 3.55 | 7.87 | | |
| 332.6285 | 4.47 | 346.56 | 7.49 | 1.37 | 7.36 | | |
| 332.6354 | 4.58 | 344.56 | 8.54 | 1.34 | 8.44 | | |
| 332.6424 | 4.58 | 352.56 | 9.33 | 1.20 | 9.25 | | |
| 332.6493 | 5.03 | 356.56 | 10.03 | -0.01 | 10.03 | | |
| 332.6563 | 5.14 | 352.26 | 11.64 | -0.91 | 11.60 | | |
| 332.6632 | 5.59 | 357.16 | 12.28 | -1.60 | 12.18 | | |
| 332.6701 | 5.81 | 358.66 | 11.59 | -1.72 | 11.47 | | |
| 332.6771 | 6.26 | 355.96 | 11.59 | -1.72 | 11.47 | | |
| 332.6840 | 6.83 | 358.86 | 13.93 | -2.68 | 13.67 | | |
| 332.6910 | 7.18 | 3.16 | 12.83 | -2.83 | 12.51 | | |
| 332.6979 | 7.52 | 7.06 | 15.10 | -3.16 | 14.77 | | |
| 332.7049 | 7.87 | 5.26 | 15.19 | -1.98 | 15.06 | | |
| 332.7118 | 7.18 | 4.46 | 13.49 | -1.89 | 13.36 | | |
| 332.7188 | 8.22 | 8.36 | 14.49 | -4.29 | 13.84 | | |
| 332.7257 | 9.03 | 12.16 | 15.04 | -2.53 | 14.82 | | |
| 332.7326 | 9.38 | 23.56 | 14.70 | -2.19 | 14.54 | | |
| 332.7396 | 9.73 | 24.46 | 15.31 | 0.09 | 15.31 | | |
| 332.7465 | 9.73 | 27.86 | 15.04 | 1.33 | 14.98 | | |
| 332.7535 | 9.97 | 22.96 | 15.34 | -0.36 | 15.33 | | |
| 332.7604 | 9.74 | 16.76 | 15.57 | -0.88 | 15.54 | | |
| 332.7674 | 9.98 | 12.96 | 16.35 | -2.46 | 16.16 | | |
| 332.7743 | 10.44 | 15.06 | 15.92 | -3.30 | 15.58 | | |
| 332.7813 | 10.10 | 15.76 | 15.49 | -3.32 | 15.13 | | |
| 332.7882 | 10.80 | 18.56 | 16.37 | 0.51 | 16.36 | | |
| 332.7951 | 10.81 | 18.66 | 15.75 | -4.21 | 15.18 | | |
| 332.8021 | 11.16 | 15.66 | 16.26 | -5.19 | 15.41 | | |
| 332.8090 | 12.45 | 16.76 | 18.60 | -7.43 | 17.05 | | |
| 332.8160 | 12.69 | 19.96 | 17.83 | -6.19 | 16.72 | | |
| 332.8229 | 13.16 | 19.36 | 20.25 | -6.79 | 19.08 | | |
| 332.8299 | 13.75 | 20.06 | 18.59 | -3.79 | 18.20 | | |
| 332.8368 | 13.99 | 21.46 | 17.82 | -4.46 | 17.25 | | |
| 332.8438 | 14.34 | 19.26 | 19.92 | -5.89 | 19.03 | | |
| 332.8507 | 14.46 | 17.86 | 20.20 | -8.25 | 18.44 | | |
| 332.8576 | 14.34 | 18.86 | 19.24 | -8.77 | 17.12 | | |
| 332.8646 | 14.11 | 18.86 | 19.24 | -6.57 | 18.08 | | |
| 332.8715 | 15.28 | 17.66 | 19.60 | -7.65 | 18.05 | | |
| 332.8785 | 14.93 | 16.46 | 21.46 | -7.08 | 20.26 | | |
| 332.8854 | 15.52 | 16.76 | 18.64 | -8.53 | 16.57 | | |
| 332.8924 | 15.76 | 17.86 | 22.71 | -11.04 | 19.84 | | |
| 332.8993 | 15.88 | 15.96 | 21.31 | -11.69 | 17.81 | | |
| 332.9063 | 15.06 | 17.56 | 24.10 | -11.60 | 21.12 | | |
| 332.9132 | 15.42 | 21.86 | 24.22 | -10.58 | 21.79 | | |
| 332.9201 | 15.53 | 18.76 | 20.45 | -9.43 | 18.14 | | |
| 332.9271 | 16.00 | 20.66 | 19.89 | -10.95 | 16.61 | | |

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | 5.5m Leeway Speed (cm/s) | Boat Eastward Leeway (cm/s) | Run 60 Northward Leeway (cm/s) | Life Raft Leeway Speed (cm/s) | "J" Eastward Leeway (cm/s) | Run 63 Northward Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 332.9340 | 16.12 | | | | 14.87 | -8.40 | 12.27 |
| 332.9410 | 16.25 | | | | 10.07 | -5.09 | 8.69 |
| 332.9479 | 16.25 | 46.10 | 44.52 | 11.98 | 10.47 | -5.25 | 9.05 |
| 332.9549 | 16.37 | 43.95 | 43.23 | 7.93 | 13.60 | -5.43 | 12.47 |
| 332.9618 | 16.49 | 44.34 | 43.60 | 8.09 | 17.61 | -6.48 | 16.37 |
| 332.9688 | 17.20 | 40.75 | 40.47 | 4.76 | 11.66 | -3.53 | 11.11 |
| 332.9757 | 16.26 | 41.60 | 41.56 | 1.75 | 15.65 | -7.33 | 13.82 |
| 332.9826 | 16.61 | 39.40 | 39.39 | 1.24 | 16.01 | -6.94 | 14.43 |
| 332.9896 | 16.74 | 41.95 | 41.87 | 2.54 | 12.41 | -5.32 | 11.21 |
| 332.9965 | 16.98 | 42.18 | 42.02 | 3.69 | 12.21 | -5.24 | 11.02 |
| 333.0035 | 16.75 | 40.52 | 40.49 | 1.72 | 18.42 | -6.62 | 17.19 |
| 333.0104 | 16.75 | 43.39 | 43.15 | 4.62 | 12.61 | -5.40 | 11.39 |
| 333.0174 | 16.28 | 38.74 | 38.70 | 1.81 | 14.31 | -2.03 | 14.17 |
| 333.0243 | 15.11 | 35.91 | 35.89 | 1.24 | 14.17 | -3.58 | 13.71 |
| 333.0313 | 15.48 | 33.08 | 32.09 | -8.05 | 12.88 | -3.83 | 12.29 |
| 333.0382 | 15.37 | 30.42 | 30.32 | -2.50 | 10.80 | -4.31 | 9.90 |
| 333.0451 | 15.02 | 31.21 | 30.96 | -3.96 | 10.01 | -3.63 | 9.33 |
| 333.0521 | 15.15 | 33.52 | 33.15 | -4.97 | 13.82 | -4.78 | 12.97 |
| 333.0590 | 14.46 | 32.04 | 31.75 | -4.27 | 11.20 | -4.29 | 10.35 |
| 333.0660 | 14.11 | 29.62 | 29.21 | -4.94 | 8.84 | -2.78 | 8.39 |
| 333.0729 | 14.58 | 29.70 | 29.63 | -1.92 | 11.59 | -1.72 | 11.47 |
| 333.0799 | 14.46 | 34.21 | 32.81 | -9.70 | 8.27 | 1.24 | 8.17 |
| 333.0868 | 15.04 | 31.40 | 29.32 | -11.22 | 9.65 | -1.74 | 9.50 |
| 333.0938 | 15.15 | 29.68 | 29.31 | -4.68 | 8.29 | -0.55 | 8.27 |
| 333.1007 | 13.98 | 29.79 | 29.39 | -4.86 | 8.20 | -1.55 | 8.05 |
| 333.1076 | 13.06 | 29.40 | 28.56 | -6.97 | 8.41 | -0.81 | 8.37 |
| 333.1146 | 12.38 | 29.20 | 27.84 | -8.81 | 10.69 | -1.14 | 10.63 |
| 333.1215 | 12.03 | 31.72 | 30.10 | -10.01 | 5.92 | -1.22 | 5.80 |
| 333.1285 | 10.66 | 26.17 | 24.61 | -8.91 | 12.27 | -0.97 | 12.23 |
| 333.1354 | 10.55 | 29.07 | 28.55 | -5.45 | 12.17 | -2.96 | 11.80 |
| 333.1424 | 11.16 | 27.93 | 27.04 | -6.98 | 7.98 | -0.21 | 7.98 |
| 333.1493 | 11.75 | 23.26 | 22.21 | -6.90 | 8.16 | 1.05 | 8.09 |
| 333.1563 | 11.97 | 27.99 | 27.75 | -3.61 | 8.69 | -0.08 | 8.69 |
| 333.1632 | 12.09 | 22.28 | 21.34 | -6.41 | 5.66 | 0.83 | 5.60 |
| 333.1701 | 12.54 | 26.60 | 25.06 | -8.94 | 8.56 | 2.05 | 8.31 |
| 333.1771 | 12.89 | 23.62 | 22.03 | -8.51 | 6.51 | 2.64 | 5.95 |
| 333.1840 | 11.85 | 23.64 | 21.62 | -9.56 | 8.35 | 3.18 | 7.71 |
| 333.1910 | 12.88 | 22.40 | 19.58 | -10.89 | 7.25 | 1.98 | 6.97 |
| 333.1979 | 13.69 | 17.37 | 13.77 | -10.58 | 6.37 | 2.46 | 5.87 |
| 333.2049 | 13.23 | 21.65 | 19.88 | -8.57 | 7.09 | 3.11 | 6.37 |
| 333.2118 | 13.00 | 19.25 | 16.40 | -10.09 | 5.12 | 2.39 | 4.53 |
| 333.2188 | 12.76 | 17.69 | 16.19 | -7.12 | 9.25 | 2.44 | 8.92 |
| 333.2257 | 13.11 | 20.79 | 19.50 | -7.21 | 7.89 | 4.64 | 6.38 |
| 333.2326 | 13.57 | 19.29 | 18.42 | -5.72 | 10.93 | 4.90 | 9.77 |
| 333.2396 | 13.34 | 18.87 | 18.07 | -5.43 | 8.06 | 2.82 | 7.55 |
| 333.2465 | 14.15 | 19.21 | 18.54 | -5.01 | 7.40 | 3.48 | 6.53 |
| 333.2535 | 14.26 | 17.71 | 17.70 | -0.58 | 9.77 | 5.10 | 8.33 |

Swamped Boat and Life Raft

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | 5.5m Leeway Speed (cm/s) | Boat Eastward Leeway (cm/s) | Run 60 Northward Leeway (cm/s) | Life Raft Leeway Speed (cm/s) | "J" Eastward Leeway (cm/s) | Run 63 Northward Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 333.2604 | 14.03 | 20.43 | 20.43 | 0.18 | 9.60 | 5.52 | 7.86 |
| 333.2674 | 14.37 | 19.80 | 19.77 | 1.20 | 11.21 | 5.88 | 9.54 |
| 333.2743 | 14.13 | 20.62 | 20.58 | 1.33 | 12.91 | 5.63 | 11.62 |
| 333.2813 | 13.43 | 22.65 | 22.52 | 2.39 | 8.03 | 5.93 | 5.42 |
| 333.2882 | 13.54 | 18.08 | 18.07 | -0.42 | 11.56 | 7.88 | 8.45 |
| 333.2951 | 13.30 | 21.74 | 21.72 | -0.79 | 9.85 | 6.65 | 7.26 |
| 333.3021 | 13.29 | 16.71 | 16.53 | -2.39 | 10.94 | 8.18 | 7.27 |
| 333.3090 | 12.02 | 19.95 | 19.91 | -1.14 | 9.65 | 8.40 | 4.75 |
| 333.3160 | 11.44 | 15.54 | 15.38 | -2.24 | 13.89 | 11.35 | 8.00 |
| 333.3229 | 10.98 | 14.98 | 14.72 | -2.75 | 10.60 | 9.64 | 4.42 |
| 333.3299 | 10.86 | 12.45 | 11.69 | -4.29 | 8.91 | 7.51 | 4.80 |
| 333.3368 | 10.97 | 13.75 | 13.13 | -4.10 | 9.31 | 7.29 | 5.80 |
| 333.3438 | 11.31 | 13.21 | 13.06 | -1.94 | 10.77 | 8.42 | 6.72 |
| 333.3507 | 10.52 | 13.29 | 12.37 | -4.86 | 9.02 | 7.27 | 5.35 |
| 333.3576 | 10.63 | 11.22 | 10.76 | -3.17 | 9.23 | 6.95 | 6.08 |
| 333.3646 | 10.86 | 13.21 | 12.94 | -2.65 | 8.10 | 6.27 | 5.13 |
| 333.3715 | 11.19 | 11.03 | 10.16 | -4.30 | 11.61 | 9.57 | 6.57 |
| 333.3785 | 11.87 | 11.00 | 10.70 | -2.54 | 10.22 | 9.11 | 4.62 |
| 333.3854 | 14.20 | 10.32 | 10.10 | -2.14 | 15.02 | 14.07 | 5.26 |
| 333.3924 | 15.24 | 10.21 | 10.02 | -1.96 | 17.57 | 17.21 | 3.57 |
| 333.3993 | 16.05 | 7.38 | 7.28 | -1.19 | 15.63 | 14.70 | 5.31 |
| 333.4063 | 16.51 | 8.20 | 8.05 | 1.55 | 11.54 | 11.17 | 2.90 |
| 333.4132 | 14.39 | 5.65 | 5.65 | 0.06 | 13.18 | 12.80 | 3.18 |
| 333.4201 | 14.15 | 7.21 | 6.44 | 3.24 | 12.24 | 11.96 | 2.59 |
| 333.4271 | 13.21 | 5.99 | 3.91 | 4.54 | 10.79 | 10.52 | 2.40 |
| 333.4340 | 12.98 | 8.22 | 2.47 | 7.84 | 11.02 | 10.92 | 1.48 |
| 333.4410 | 13.56 | 9.81 | -3.55 | 9.14 | 12.63 | 12.63 | 0.05 |
| 333.4479 | 14.15 | 10.41 | -3.79 | 9.69 | 15.98 | 15.70 | -2.98 |
| 333.4549 | 15.79 | 17.53 | -2.13 | 17.40 | 14.71 | 13.59 | -5.64 |
| 333.4618 | 16.48 | 16.26 | -5.19 | 15.41 | 15.70 | 14.56 | -5.87 |
| 333.4688 | 15.87 | 17.85 | -4.28 | 17.33 | 13.72 | 13.36 | -3.12 |
| 333.4757 | 15.63 | 19.07 | -11.28 | 15.37 | 12.78 | 12.26 | -3.60 |
| 333.4826 | 14.80 | 21.11 | -16.02 | 13.74 | 19.66 | 18.24 | -7.32 |
| 333.4896 | 14.45 | 22.53 | -14.50 | 17.25 | 19.37 | 16.58 | -10.01 |
| 333.4965 | 16.33 | 23.29 | -16.98 | 15.94 | 22.05 | 19.52 | -10.26 |
| 333.5035 | 16.44 | 24.80 | -14.62 | 20.03 | 17.84 | 15.57 | -8.70 |
| 333.5104 | 15.60 | 30.42 | -18.24 | 24.34 | 13.56 | 11.83 | -6.63 |
| 333.5174 | 16.07 | 30.86 | -23.68 | 19.79 | 17.96 | 15.76 | -8.62 |
| 333.5243 | 16.19 | 30.17 | -23.93 | 18.37 | 16.00 | 13.91 | -7.90 |
| 333.5313 | 15.47 | 26.40 | -16.75 | 20.41 | 14.42 | 12.13 | -7.81 |
| 333.5382 | 15.00 | 24.35 | -16.52 | 17.89 | 14.30 | 13.04 | -5.88 |
| 333.5451 | 16.54 | 27.56 | -20.62 | 18.28 | 16.20 | 13.50 | -8.95 |
| 333.5521 | 15.23 | 34.65 | -24.60 | 24.41 | 16.86 | 14.21 | -9.08 |
| 333.5590 | 15.59 | 34.93 | -24.10 | 25.28 | 11.49 | 9.42 | -6.59 |
| 333.5660 | 14.64 | 30.51 | -22.94 | 20.11 | 10.39 | 8.36 | -6.17 |
| 333.5729 | 14.17 | 30.23 | -19.94 | 22.73 | 14.40 | 11.16 | -9.10 |
| 333.5799 | 14.87 | 29.75 | -20.82 | 21.25 | 16.09 | 13.71 | -8.43 |

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | 5.5m Leeway Speed (cm/s) | Boat Eastward Leeway (cm/s) | Run 60 Northward Leeway (cm/s) | Life Raft Leeway Speed (cm/s) | "J" Eastward Leeway (cm/s) | Run 63 Northward Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 333.5868 | 14.40 | 30.22 | -18.16 | 24.16 | 10.66 | 7.77 | -7.31 |
| 333.5938 | 13.92 | 32.69 | -15.22 | 28.93 | 12.73 | 10.26 | -7.53 |
| 333.6007 | 14.39 | 34.40 | -13.74 | 31.54 | 14.13 | 10.90 | -8.99 |
| 333.6076 | 14.39 | 35.21 | -13.51 | 32.51 | 14.58 | 10.96 | -9.62 |
| 333.6146 | 14.62 | 36.48 | -12.34 | 34.33 | 14.51 | 11.63 | -8.67 |
| 333.6215 | 14.97 | 36.80 | -15.07 | 33.58 | 14.27 | 11.66 | -8.23 |
| 333.6285 | 14.37 | 39.72 | -26.28 | 29.78 | 13.06 | 10.13 | -8.24 |
| 333.6354 | 13.90 | 37.75 | -22.40 | 30.38 | 15.41 | 12.32 | -9.25 |
| 333.6424 | 12.95 | 40.58 | -25.85 | 31.28 | 12.25 | 9.34 | -7.93 |
| 333.6493 | 13.07 | 37.34 | -21.40 | 30.60 | 13.89 | 10.06 | -9.58 |
| 333.6563 | 12.60 | 38.71 | -24.11 | 30.29 | 18.02 | 13.05 | -12.42 |
| 333.6632 | 11.19 | 40.74 | -29.03 | 28.58 | 13.17 | 10.60 | -7.81 |
| 333.6701 | 11.65 | 43.05 | -30.93 | 29.94 | 9.67 | 7.18 | -6.47 |
| 333.6771 | 12.24 | 47.50 | -31.44 | 35.60 | 10.66 | 7.77 | -7.31 |
| 333.6840 | 11.77 | 48.52 | -31.55 | 36.86 | 11.99 | 9.08 | -7.82 |
| 333.6910 | 10.83 | 48.86 | -36.44 | 32.55 | 11.21 | 9.54 | -5.88 |
| 333.6979 | 11.18 | 50.47 | -35.64 | 35.74 | 10.72 | 9.30 | -5.33 |
| 333.7049 | 11.30 | 48.06 | -33.85 | 34.12 | 18.92 | 15.85 | -10.33 |
| 333.7118 | 12.23 | 52.71 | -41.45 | 32.55 | 10.26 | 8.57 | -5.65 |
| 333.7188 | 10.83 | 53.85 | -41.54 | 34.26 | 14.40 | 10.88 | -9.44 |
| 333.7257 | 10.25 | 54.48 | -43.79 | 32.40 | 10.73 | 8.24 | -6.88 |
| 333.7326 | 10.71 | 56.26 | -43.34 | 35.87 | 9.43 | 6.63 | -6.71 |
| 333.7396 | 10.95 | 56.19 | -47.01 | 30.78 | 11.37 | 8.37 | -7.70 |
| 333.7465 | 10.25 | 58.08 | -48.57 | 31.85 | 9.50 | 7.68 | -5.60 |
| 333.7535 | 10.36 | 56.19 | -47.40 | 30.18 | 10.11 | 7.53 | -6.76 |
| 333.7604 | 10.59 | 59.16 | -51.39 | 29.31 | 11.46 | 9.13 | -6.93 |
| 333.7674 | 10.13 | 56.14 | -47.50 | 29.91 | 8.68 | 6.60 | -5.63 |
| 333.7743 | 9.55 | 57.69 | -47.05 | 33.38 | 8.62 | 6.13 | -6.06 |
| 333.7813 | 9.20 | 59.03 | -50.32 | 30.87 | 9.48 | 7.39 | -5.94 |
| 333.7882 | 9.20 | 55.73 | -47.94 | 28.41 | 7.05 | 5.98 | -3.72 |
| 333.7951 | 9.89 | 59.76 | -51.81 | 29.78 | 6.88 | 5.90 | -3.54 |
| 333.8021 | 9.54 | 56.53 | -47.95 | 29.94 | 8.77 | 7.46 | -4.60 |
| 333.8090 | 9.43 | 47.32 | -34.28 | 32.62 | 10.07 | 7.06 | -7.18 |
| 333.8160 | 9.08 | 21.27 | -11.51 | 17.89 | 6.65 | 3.37 | -5.73 |
| 333.8229 | 9.43 | 18.25 | -13.89 | 11.84 | 8.20 | 4.85 | -6.61 |
| 333.8299 | 9.08 | 21.69 | -12.69 | 17.60 | 7.84 | 5.34 | -5.75 |
| 333.8368 | 8.97 | 20.72 | -10.25 | 18.01 | 7.81 | 4.69 | -6.25 |
| 333.8438 | 8.62 | 16.88 | -8.18 | 14.76 | 6.71 | 4.39 | -5.07 |
| 333.8507 | 8.39 | 20.65 | -9.51 | 18.33 | 7.97 | 5.24 | -6.01 |
| 333.8576 | 8.50 | 18.09 | -10.88 | 14.46 | 8.16 | 5.32 | -6.19 |
| 333.8646 | 8.62 | 17.75 | -10.90 | 14.01 | 6.71 | 3.74 | -5.57 |
| 333.8715 | 8.39 | 19.83 | -6.99 | 18.55 | 5.19 | 3.28 | -4.02 |
| 333.8785 | 8.28 | 19.84 | -9.01 | 17.67 | 5.95 | 4.07 | -4.33 |
| 333.8854 | 7.82 | 19.42 | -8.48 | 17.47 | 6.80 | 5.33 | -4.22 |
| 333.8924 | 7.71 | 15.45 | -5.05 | 14.60 | 7.17 | 5.20 | -4.93 |
| 333.8993 | 8.28 | 15.62 | -5.50 | 14.62 | 7.21 | 4.92 | -5.28 |
| 333.9063 | 8.16 | 13.81 | -4.96 | 12.89 | 8.41 | 5.58 | -6.30 |

Swamped Boat and Life Raft

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | 5.5m Leeway Speed (cm/s) | Boat Eastward Leeway (cm/s) | Run 60 Northward Leeway (cm/s) | Life Raft Leeway Speed (cm/s) | "J" Eastward Leeway (cm/s) | Run 63 Northward Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 333.9132 | 7.59 | 14.41 | -5.20 | 13.44 | 7.17 | 5.20 | -4.93 |
| 333.9201 | 7.93 | 13.67 | -4.15 | 13.03 | 8.33 | 6.15 | -5.61 |
| 333.9271 | 8.05 | 15.03 | -5.08 | 14.15 | 7.96 | 5.99 | -5.24 |
| 333.9340 | 8.05 | 14.00 | 5.25 | 12.98 | 5.30 | 2.99 | -4.37 |
| 333.9410 | 8.04 | 16.39 | 0.06 | 16.39 | 7.59 | 5.08 | -5.64 |
| 333.9479 | 7.25 | 15.64 | -0.70 | 15.62 | 7.02 | 4.84 | -5.09 |
| 333.9549 | 7.47 | 16.39 | 0.06 | 16.39 | 6.75 | 3.92 | -5.49 |
| 333.9618 | 8.16 | 15.34 | -3.06 | 15.03 | 7.15 | 4.73 | -5.36 |
| 333.9688 | 8.73 | 14.47 | -3.11 | 14.14 | 6.26 | 4.05 | -4.78 |
| 333.9757 | 8.27 | 14.83 | -3.45 | 14.42 | 5.34 | 3.18 | -4.29 |
| 333.9826 | 8.50 | 15.26 | -4.79 | 14.49 | 5.85 | 3.05 | -5.00 |
| 333.9896 | 8.61 | 13.97 | -3.50 | 13.53 | 5.39 | 3.36 | -4.21 |
| 333.9965 | 8.72 | 12.86 | -1.84 | 12.73 | 7.42 | 4.53 | -5.88 |
| 334.0035 | 9.30 | 10.33 | -1.61 | 10.21 | 7.27 | 3.79 | -6.20 |
| 334.0104 | 8.95 | 6.28 | -1.56 | 6.08 | 8.59 | 5.01 | -6.98 |
| 334.0174 | 9.06 | 9.33 | 1.20 | 9.25 | 8.10 | 5.13 | -6.27 |
| 334.0243 | 9.18 | 17.29 | 5.26 | 16.47 | 8.54 | 5.48 | -6.56 |
| 334.0313 | 9.06 | 14.21 | -5.31 | 13.18 | 8.16 | 4.66 | -6.69 |
| 334.0382 | 9.75 | 11.91 | -3.25 | 11.46 | 8.25 | 5.03 | -6.54 |
| 334.0451 | 9.06 | 12.85 | -0.58 | 12.84 | 5.53 | 3.26 | -4.47 |
| 334.0521 | 9.75 | 13.33 | 0.97 | 13.29 | 6.46 | 4.13 | -4.96 |
| 334.0590 | 10.21 | 15.75 | 1.45 | 15.69 | 11.59 | 7.22 | -9.07 |
| 334.0660 | 11.01 | 16.25 | -1.38 | 16.20 | 11.06 | 6.51 | -8.94 |
| 334.0729 | 11.01 | 14.67 | 1.04 | 14.63 | 12.00 | 6.73 | -9.94 |
| 334.0799 | 10.66 | 13.48 | 2.05 | 13.33 | 8.52 | 4.64 | -7.14 |
| 334.0868 | 10.42 | 16.41 | 6.53 | 15.06 | 8.71 | 4.72 | -7.32 |
| 334.0938 | 9.96 | 17.00 | 8.39 | 14.78 | 7.96 | 4.58 | -6.51 |
| 334.1007 | 10.54 | 18.54 | -0.01 | 18.54 | 11.24 | 5.39 | -9.87 |
| 334.1076 | 10.30 | 16.98 | 6.73 | 15.59 | 8.66 | 4.35 | -7.48 |
| 334.1146 | 10.42 | 14.37 | 2.80 | 14.09 | 6.71 | 3.74 | -5.57 |
| 334.1215 | 10.41 | 13.60 | 4.18 | 12.95 | 10.36 | 5.72 | -8.63 |
| 334.1285 | 10.07 | 19.98 | 6.11 | 19.02 | 7.67 | 3.95 | -6.57 |
| 334.1354 | 10.18 | 14.65 | 8.25 | 12.10 | 6.03 | 2.95 | -5.26 |
| 334.1424 | 10.41 | 15.19 | 6.72 | 13.62 | 7.67 | 4.79 | -5.98 |
| 334.1493 | 10.30 | 15.19 | 4.35 | 14.55 | 7.18 | 4.26 | -5.78 |
| 334.1563 | 9.83 | 13.84 | 6.73 | 12.09 | 6.23 | 3.03 | -5.44 |
| 334.1632 | 9.72 | 15.73 | 6.66 | 14.25 | 8.52 | 4.64 | -7.14 |
| 334.1701 | 9.95 | 16.20 | 8.95 | 13.50 | 8.20 | 4.85 | -6.61 |
| 334.1771 | 10.06 | 14.45 | 4.49 | 13.74 | 7.50 | 4.06 | -6.30 |
| 334.1840 | 9.37 | 11.88 | 6.00 | 10.25 | 6.99 | 4.18 | -5.59 |
| 334.1910 | 9.71 | 13.81 | 7.34 | 11.70 | 7.03 | 3.35 | -6.18 |
| 334.1979 | 9.48 | 12.00 | 5.92 | 10.44 | 7.20 | 3.06 | -6.52 |
| 334.2049 | 9.60 | 12.19 | 5.24 | 11.01 | 7.86 | 4.87 | -6.17 |
| 334.2118 | 9.94 | 13.15 | 4.68 | 12.29 | 6.20 | 2.66 | -5.60 |
| 334.2188 | 9.60 | 11.65 | 5.29 | 10.38 | 7.77 | 4.50 | -6.33 |
| 334.2257 | 8.91 | 14.68 | 7.04 | 12.88 | 7.89 | 4.22 | -6.67 |
| 334.2326 | 9.60 | 15.04 | 9.22 | 11.87 | 8.04 | 3.93 | -7.01 |

Swamped Boat and Life Raft

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | 5.5m Leeway Speed (cm/s) | Boat Eastward Leeway (cm/s) | Run 60 Northward Leeway (cm/s) | Life Raft Leeway Speed (cm/s) | "J" Eastward Leeway (cm/s) | Run 63 Northward Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 334.2396 | 9.71 | 18.94 | 13.34 | 13.45 | 7.64 | 3.77 | -6.65 |
| 334.2465 | 9.25 | 18.03 | 16.10 | 8.11 | 7.89 | 4.22 | -6.67 |
| 334.2535 | 9.25 | 18.49 | 17.59 | 5.70 | 6.26 | 4.80 | -4.02 |
| 334.2604 | 9.60 | 18.93 | 16.36 | 9.53 | 7.62 | 4.61 | -6.06 |
| 334.2674 | 8.68 | 18.09 | 15.78 | 8.84 | 7.24 | 3.61 | -6.28 |
| 334.2743 | 8.45 | 17.61 | 14.25 | 10.35 | 7.23 | 4.45 | -5.70 |
| 334.2813 | 8.68 | 16.42 | 14.72 | 7.28 | 8.12 | 4.48 | -6.77 |
| 334.2882 | 9.49 | 15.13 | 12.95 | 7.83 | 6.00 | 2.58 | -5.42 |
| 334.2951 | 9.26 | 16.22 | 14.53 | 7.20 | 6.01 | 2.76 | -5.34 |
| 334.3021 | 9.60 | 14.76 | 14.26 | 3.82 | 6.20 | 2.66 | -5.60 |
| 334.3090 | 9.14 | 15.95 | 15.36 | 4.29 | 8.02 | 2.65 | -7.57 |
| 334.3160 | 9.03 | 19.37 | 19.21 | 2.48 | 6.81 | 3.08 | -6.07 |
| 334.3229 | 9.72 | 19.80 | 19.53 | -3.27 | 6.68 | 3.55 | -5.65 |
| 334.3299 | 9.37 | 19.52 | 19.51 | -0.22 | 7.41 | 2.59 | -6.94 |
| 334.3368 | 8.69 | 18.19 | 17.97 | 2.81 | 6.61 | 3.00 | -5.89 |
| 334.3438 | 9.15 | 17.80 | 17.76 | -1.21 | 7.41 | 3.32 | -6.62 |
| 334.3507 | 9.15 | 19.65 | 18.99 | -5.03 | 5.80 | 2.32 | -5.32 |
| 334.3576 | 8.57 | 16.28 | 14.88 | -6.61 | 7.64 | 2.30 | -7.29 |
| 334.3646 | 8.92 | 18.80 | 18.20 | -4.72 | 6.01 | 2.03 | -5.66 |
| 334.3715 | 9.26 | 21.81 | 20.68 | -6.91 | 5.26 | 1.34 | -5.09 |
| 334.3785 | 8.91 | 18.84 | 16.44 | -9.20 | 7.00 | 2.98 | -6.34 |
| 334.3854 | 9.03 | 15.03 | 13.54 | -6.54 | 6.80 | 2.72 | -6.23 |
| 334.3924 | 8.92 | 17.84 | 17.33 | -4.23 | 7.82 | 2.57 | -7.39 |
| 334.3993 | 8.92 | 16.53 | 14.05 | -8.71 | 6.43 | 2.01 | -6.11 |
| 334.4063 | 8.92 | 12.61 | 12.58 | -0.84 | 6.20 | 2.66 | -5.60 |
| 334.4132 | 8.92 | 17.55 | 16.53 | -5.89 | 6.84 | 0.99 | -6.77 |
| 334.4201 | 8.92 | 12.53 | 12.10 | -3.24 | 6.65 | 0.91 | -6.59 |
| 334.4271 | 9.38 | 17.21 | 16.60 | -4.55 | 6.60 | 1.09 | -6.51 |
| 334.4340 | 9.15 | 13.68 | 13.26 | -3.39 | 5.49 | 1.24 | -5.35 |
| 334.4410 | 8.57 | 16.31 | 14.67 | -7.13 | 8.62 | 2.89 | -8.12 |
| 334.4479 | 8.46 | 19.04 | 12.87 | -14.02 | 6.75 | 1.35 | -6.61 |
| 334.4549 | 9.49 | 12.59 | 11.77 | -4.47 | 6.20 | 2.48 | -5.68 |
| 334.4618 | 8.92 | 8.14 | 8.12 | -0.61 | 7.50 | 4.06 | -6.30 |
| 334.4688 | 9.38 | 16.01 | 12.17 | -10.40 | 6.05 | 1.66 | -5.82 |
| 334.4757 | 8.69 | 15.09 | 11.87 | 9.32 | 7.41 | 2.59 | -6.94 |
| 334.4826 | 9.61 | 15.49 | 13.78 | -7.09 | 6.43 | 2.01 | -6.11 |
| 334.4896 | 9.04 | 15.14 | 12.73 | -8.20 | 5.43 | 1.61 | -5.19 |
| 334.4965 | 8.35 | 17.28 | 12.73 | -11.69 | 7.18 | 1.33 | -7.06 |
| 334.5035 | 8.70 | 16.16 | 15.75 | -3.61 | 5.85 | 1.58 | -5.64 |
| 334.5104 | 9.50 | 12.09 | 11.99 | 1.52 | 5.39 | 0.79 | -5.33 |
| 334.5174 | 9.16 | 7.81 | 7.50 | -2.19 | 6.91 | 1.62 | -6.71 |
| 334.5243 | 9.27 | 10.48 | 9.53 | -4.35 | 5.23 | 1.53 | -5.01 |
| 334.5313 | 8.58 | 18.86 | 15.95 | -10.07 | 5.04 | 1.45 | -4.82 |
| 334.5382 | 8.36 | 16.29 | 14.77 | -6.87 | 5.53 | 1.06 | -5.43 |
| 334.5451 | 8.47 | 12.87 | 12.03 | -4.58 | 5.30 | 1.16 | -5.17 |
| 334.5521 | 7.79 | 14.43 | 13.53 | -5.01 | 4.95 | 0.82 | -4.88 |
| 334.5590 | 8.36 | 16.77 | 16.15 | -4.52 | 5.73 | 1.14 | -5.61 |

Swamped Boat and Life Raft

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | 5.5m Leeway Speed (cm/s) | Boat Eastward Leeway (cm/s) | Run 60 Northward Leeway (cm/s) | Life Raft Leeway Speed (cm/s) | "J" Eastward Leeway (cm/s) | Run 63 Northward Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 334.5660 | 8.93 | 19.09 | 18.70 | -3.85 | 5.39 | 0.79 | -5.33 |
| 334.5729 | 8.58 | 19.42 | 14.55 | -12.86 | 6.87 | 1.80 | -6.63 |
| 334.5799 | 8.36 | 16.55 | 16.52 | -0.87 | 5.80 | 2.13 | -5.40 |
| 334.5868 | 8.01 | 15.93 | 14.12 | -7.37 | 7.33 | 1.59 | -7.16 |
| 334.5938 | 7.56 | 14.99 | 12.26 | -8.62 | 5.10 | 1.08 | -4.98 |
| 334.6007 | 7.56 | 14.76 | 11.61 | -9.12 | 5.63 | 0.69 | -5.59 |
| 334.6076 | 7.90 | 15.99 | 15.03 | -5.45 | 5.44 | 0.61 | -5.41 |
| 334.6146 | 7.56 | 21.43 | 19.20 | -9.52 | 4.75 | 0.11 | -4.75 |
| 334.6215 | 7.33 | 16.42 | 13.87 | -8.79 | 4.32 | 0.76 | -4.25 |
| 334.6285 | 6.99 | 16.53 | 14.05 | -8.71 | 5.50 | 0.43 | -5.49 |
| 334.6354 | 6.99 | 18.97 | 16.13 | -9.99 | 4.67 | 1.10 | -4.54 |
| 334.6424 | 7.11 | 14.76 | 12.29 | -8.17 | 5.14 | 0.90 | -5.06 |
| 334.6493 | 7.33 | 17.09 | 14.58 | -8.92 | 5.46 | 1.42 | -5.27 |
| 334.6563 | 6.99 | 17.58 | 14.82 | -9.47 | 4.95 | 0.82 | -4.88 |
| 334.6632 | 7.45 | 15.43 | 10.42 | -11.39 | 5.63 | 0.69 | -5.59 |
| 334.6701 | 7.56 | 18.68 | 13.18 | -13.24 | 4.68 | 0.29 | -4.67 |
| 334.6771 | 6.54 | 16.37 | 12.33 | -10.77 | 5.46 | 1.42 | -5.27 |
| 334.6840 | 6.88 | 14.34 | 11.55 | -8.49 | 5.06 | 0.45 | -5.04 |
| 334.6910 | 7.79 | 20.67 | 16.25 | -12.77 | 5.63 | 1.69 | -5.37 |
| 334.6979 | 7.90 | 19.23 | 14.75 | -12.33 | 5.41 | 1.79 | -5.11 |
| 334.7049 | 7.11 | 17.26 | 13.30 | -11.00 | 5.89 | 1.40 | -5.72 |
| 334.7118 | 8.01 | 17.75 | 14.90 | -9.65 | 4.71 | 0.92 | -4.62 |
| 334.7188 | 7.67 | 19.35 | 15.51 | -11.57 | 5.26 | 1.34 | -5.09 |
| 334.7257 | 8.13 | 14.70 | 12.39 | -7.91 | 4.87 | 1.18 | -4.72 |
| 334.7326 | 7.67 | 13.56 | 11.83 | -6.63 | 4.62 | 0.47 | -4.59 |
| 334.7396 | 7.44 | 15.60 | 11.25 | -10.80 | 4.87 | 1.18 | -4.72 |
| 334.7465 | 7.67 | 17.87 | 14.69 | -10.18 | 4.40 | 1.57 | -4.11 |
| 334.7535 | 7.56 | 17.56 | 14.14 | -10.42 | 5.26 | 1.34 | -5.09 |
| 334.7604 | 7.90 | 19.52 | 18.16 | -7.14 | 6.25 | 1.74 | -6.00 |
| 334.7674 | 8.12 | 17.02 | 13.61 | -10.21 | 6.83 | 2.17 | -6.47 |
| 334.7743 | 7.90 | 17.49 | 14.24 | -10.16 | 4.80 | 1.73 | -4.48 |
| 334.7813 | 8.01 | 17.89 | 13.44 | -11.82 | 4.60 | 1.84 | -4.22 |
| 334.7882 | 7.55 | 17.46 | 12.81 | -11.87 | 6.60 | 2.64 | -6.05 |
| 334.7951 | 7.78 | 19.16 | 12.77 | -14.29 | 5.73 | 1.14 | -5.61 |
| 334.8021 | 8.12 | 16.39 | 12.04 | -11.11 | 5.39 | 0.79 | -5.33 |
| 334.8090 | 8.12 | 18.04 | 14.77 | -10.36 | 5.00 | 1.81 | -4.66 |
| 334.8160 | 8.12 | 18.88 | 16.34 | -9.46 | 4.32 | 0.76 | -4.25 |
| 334.8229 | 8.58 | 18.36 | 13.50 | -12.45 | 5.69 | 1.32 | -5.53 |
| 334.8299 | 8.46 | 21.24 | 18.63 | -10.21 | 4.81 | 0.55 | -4.78 |
| 334.8368 | 8.35 | 16.37 | 14.46 | -7.66 | 5.82 | 0.77 | -5.77 |
| 334.8438 | 8.46 | 17.46 | 13.96 | -10.50 | 4.64 | 1.29 | -4.46 |
| 334.8507 | 8.12 | 15.77 | 9.27 | -12.76 | 6.91 | 1.62 | -6.71 |
| 334.8576 | 8.12 | 20.09 | 17.19 | -10.40 | 6.85 | 1.98 | -6.55 |
| 334.8646 | 8.92 | 19.58 | 16.56 | -10.46 | 6.03 | 1.85 | -5.74 |
| 334.8715 | 9.27 | 19.42 | 14.55 | -12.86 | 5.61 | 1.87 | -5.29 |
| 334.8785 | 8.92 | 19.00 | 15.35 | -11.20 | 4.62 | 1.47 | -4.38 |
| 334.8854 | 9.50 | 19.93 | 16.33 | -11.43 | 5.49 | 1.24 | -5.35 |

Swamped Boat and Life Raft

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | 5.5m Leeway Speed (cm/s) | Boat Eastward Leeway (cm/s) | Run 60 Northward Leeway (cm/s) | Life Raft Leeway Speed (cm/s) | "J" Eastward Leeway (cm/s) | Run 63 Northward Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 334.8924 | 9.84 | 18.42 | 12.92 | -13.13 | 6.02 | 0.85 | -5.96 |
| 334.8993 | 9.61 | 19.52 | 17.15 | -9.32 | 7.10 | 1.70 | -6.90 |
| 334.9063 | 8.80 | 20.93 | 16.23 | -13.22 | 5.83 | 1.77 | -5.56 |
| 334.9132 | 8.92 | 17.84 | 11.74 | -13.43 | 6.12 | 1.30 | -5.98 |
| 334.9201 | 8.80 | 18.88 | 16.34 | -9.46 | 6.26 | 0.75 | -6.22 |
| 334.9271 | 9.50 | 19.15 | 15.15 | -11.73 | 5.30 | 1.16 | -5.17 |
| 334.9340 | 9.50 | 16.22 | 13.11 | -9.56 | 6.32 | 1.38 | -6.16 |
| 334.9410 | 9.73 | 18.01 | 14.48 | -10.71 | 6.25 | 1.74 | -6.00 |
| 334.9479 | 9.61 | 20.18 | 13.82 | -14.70 | 6.51 | 1.46 | -6.35 |
| 334.9549 | 9.38 | 18.91 | 10.55 | -15.69 | 8.05 | 1.28 | -7.95 |
| 334.9618 | 9.49 | 15.61 | 12.69 | -9.09 | 6.36 | 1.19 | -6.24 |
| 334.9688 | 9.26 | 18.42 | 15.22 | -10.39 | 6.48 | 1.64 | -6.27 |
| 334.9757 | 9.96 | 20.47 | 17.24 | -11.03 | 6.68 | 1.72 | -6.45 |
| 334.9826 | 9.84 | 20.00 | 12.80 | -15.36 | 5.40 | 2.16 | -4.95 |
| 334.9896 | 10.18 | 15.21 | 11.95 | -9.41 | 7.05 | 2.06 | -6.74 |
| 334.9965 | 9.72 | 21.00 | 13.86 | -15.78 | 5.60 | 2.05 | -5.21 |
| 335.0035 | 9.03 | 20.28 | 14.48 | -14.20 | 5.83 | 1.77 | -5.56 |
| 335.0104 | 9.26 | 17.98 | 13.62 | -11.74 | 6.75 | 1.35 | -6.61 |
| 335.0174 | 9.49 | 17.09 | 10.95 | -13.12 | 6.28 | 1.56 | -6.08 |
| 335.0243 | 8.92 | 18.17 | 13.42 | -12.26 | 7.33 | 1.59 | -7.16 |
| 335.0313 | 9.27 | 19.77 | 15.28 | -12.54 | 8.00 | 1.47 | -7.87 |
| 335.0382 | 9.61 | 16.01 | 11.13 | -11.51 | 6.45 | 1.82 | -6.19 |
| 335.0451 | 8.92 | 17.46 | 10.46 | -13.99 | 5.97 | 1.03 | -5.88 |
| 335.0521 | 10.30 | 19.93 | 16.33 | -11.43 | 5.26 | 1.34 | -5.09 |
| 335.0590 | 9.38 | 16.51 | 9.40 | -13.57 | 5.77 | 0.95 | -5.69 |
| 335.0660 | 9.84 | 17.53 | 13.57 | -11.11 | 7.34 | 0.78 | -7.30 |
| 335.0729 | 9.95 | 15.31 | 10.05 | -11.55 | 5.80 | 2.32 | -5.32 |
| 335.0799 | 9.49 | 16.31 | 11.86 | -11.19 | 5.92 | 1.22 | -5.80 |
| 335.0868 | 9.03 | 18.56 | 15.01 | -10.91 | 7.96 | 1.65 | -7.79 |
| 335.0938 | 8.23 | 18.03 | 12.29 | -13.19 | 6.05 | 1.66 | -5.82 |
| 335.1007 | 9.38 | 17.15 | 14.08 | -9.79 | 6.51 | 1.46 | -6.35 |
| 335.1076 | 9.72 | 16.65 | 13.17 | -10.19 | 6.28 | 1.56 | -6.08 |
| 335.1146 | 9.26 | 15.49 | 11.36 | -10.54 | 7.91 | 0.39 | -7.90 |
| 335.1215 | 8.80 | 17.23 | 12.26 | -12.11 | 6.58 | 0.46 | -6.56 |
| 335.1285 | 10.19 | 19.76 | 16.25 | -11.25 | 6.39 | 0.38 | -6.38 |
| 335.1354 | 9.38 | 15.19 | 8.19 | -12.79 | 7.09 | 0.88 | -7.03 |
| 335.1424 | 9.49 | 15.97 | 9.35 | -12.94 | 7.03 | 2.25 | -6.66 |
| 335.1493 | 8.80 | 18.65 | 13.47 | -12.89 | 6.43 | 2.01 | -6.11 |
| 335.1563 | 9.03 | 15.21 | 6.44 | -13.77 | 9.22 | 1.76 | -9.05 |
| 335.1632 | 9.03 | 16.13 | 11.02 | -11.78 | 6.65 | 0.28 | -6.64 |
| 335.1701 | 8.46 | 16.01 | 11.13 | -11.51 | 6.16 | 1.11 | -6.06 |
| 335.1771 | 9.15 | 17.42 | 6.22 | -16.27 | 8.09 | 2.10 | -7.81 |
| 335.1840 | 8.80 | 15.46 | 7.44 | -13.56 | 8.01 | 2.83 | -7.49 |
| 335.1910 | 8.23 | 19.41 | 14.83 | -12.52 | 7.03 | 2.25 | -6.66 |
| 335.1979 | 9.15 | 18.63 | 10.94 | -15.09 | 7.23 | 1.15 | -7.14 |
| 335.2049 | 9.61 | 18.02 | 13.05 | -12.42 | 7.10 | 1.70 | -6.90 |
| 335.2118 | 9.15 | 18.29 | 10.96 | -14.64 | 7.27 | 1.96 | -7.00 |

Swamped Boat and Life Raft

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | 5.5m Leeway Speed (cm/s) | Boat Eastward Leeway (cm/s) | Run 60 Northward Leeway (cm/s) | Life Raft Leeway Speed (cm/s) | "J" Eastward Leeway (cm/s) | Run 63 Northward Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 335.2188 | 8.12 | 19.68 | 9.48 | -17.25 | 5.91 | -0.04 | -5.91 |
| 335.2257 | 8.69 | 17.22 | 6.14 | -16.09 | 5.82 | 0.77 | -5.77 |
| 335.2326 | 8.12 | 17.51 | 10.64 | -13.91 | 6.01 | 2.03 | -5.66 |
| 335.2396 | 8.35 | 16.12 | 9.25 | -13.21 | 6.61 | 2.27 | -6.21 |
| 335.2465 | 8.69 | 16.57 | 11.37 | -12.06 | 5.80 | 2.32 | -5.32 |
| 335.2535 | 9.95 | 16.13 | 10.55 | -12.20 | 5.30 | 1.16 | -5.17 |
| 335.2604 | 9.49 | 15.31 | 4.42 | -14.65 | 6.20 | 2.29 | -5.76 |
| 335.2674 | 8.57 | 18.14 | 11.06 | -14.38 | 5.61 | 2.60 | -4.97 |
| 335.2743 | 8.23 | 14.12 | 7.24 | -12.12 | 6.00 | 2.21 | -5.58 |
| 335.2813 | 8.57 | 17.76 | 9.23 | -15.18 | 7.03 | 3.35 | -6.18 |
| 335.2882 | 9.72 | 15.00 | 5.99 | -13.75 | 7.62 | 4.61 | -6.06 |
| 335.2951 | 8.80 | 16.52 | 8.38 | -14.24 | 8.44 | 4.09 | -7.38 |
| 335.3021 | 9.84 | 17.91 | 8.94 | -15.52 | 6.81 | 3.08 | -6.07 |
| 335.3090 | 9.49 | 15.98 | 8.51 | -13.53 | 7.80 | 3.30 | -7.07 |
| 335.3160 | 9.26 | 17.80 | 7.29 | -16.24 | 8.40 | 3.17 | -7.78 |
| 335.3229 | 9.38 | 18.00 | 7.37 | -16.42 | 6.80 | 2.90 | -6.15 |
| 335.3299 | 9.72 | 15.72 | 9.74 | -12.34 | 9.28 | 4.78 | -7.95 |
| 335.3368 | 9.15 | 17.96 | 10.33 | -14.70 | 10.80 | 4.50 | -9.82 |
| 335.3438 | 9.03 | 15.65 | 5.13 | -14.78 | 6.60 | 2.82 | -5.97 |
| 335.3507 | 8.00 | 21.35 | 13.36 | -16.65 | 6.68 | 3.55 | -5.65 |
| 335.3576 | 11.46 | 16.88 | 10.22 | -13.44 | 6.65 | 3.37 | -5.73 |
| 335.3646 | 10.88 | 18.28 | 12.08 | -13.71 | 5.61 | 2.60 | -4.97 |
| 335.3715 | 10.88 | 19.21 | 10.16 | -16.30 | 7.20 | 2.88 | -6.60 |
| 335.3785 | 11.00 | 19.20 | 7.30 | -17.76 | 6.40 | 2.74 | -5.79 |
| 335.3854 | 10.42 | 16.00 | 6.02 | -14.83 | 8.40 | 3.17 | -7.78 |
| 335.3924 | 9.72 | 16.55 | 3.35 | -16.21 | 7.22 | 3.43 | -6.36 |
| 335.3993 | 8.57 | 15.05 | 7.09 | -13.27 | 7.44 | 3.69 | -6.46 |
| 335.4063 | 10.41 | 14.40 | 5.75 | -13.20 | 7.00 | 2.98 | -6.34 |
| 335.4132 | 9.03 | 16.44 | 7.65 | -14.56 | 6.00 | 2.21 | -5.58 |
| 335.4201 | 10.53 | 19.01 | 8.14 | -17.18 | 8.41 | 3.72 | -7.54 |
| 335.4271 | 10.30 | 18.22 | 6.54 | -17.00 | 8.82 | 4.07 | -7.83 |
| 335.4340 | 10.76 | 17.87 | 5.64 | -16.96 | 7.21 | 3.24 | -6.44 |
| 335.4410 | 11.57 | 18.00 | 7.01 | -16.58 | 7.03 | 3.35 | -6.18 |
| 335.4479 | 10.06 | 18.80 | 7.51 | -17.23 | 8.06 | 4.11 | -6.93 |
| 335.4549 | 10.64 | 17.67 | 8.50 | -15.50 | 13.60 | 8.86 | -10.32 |
| 335.4618 | 10.07 | 19.94 | 5.71 | -19.11 | 8.60 | 3.62 | -7.80 |
| 335.4688 | 10.99 | 15.78 | 0.33 | -15.78 | 8.20 | 4.85 | -6.61 |
| 335.4757 | 10.76 | 15.45 | 0.62 | -15.44 | 7.53 | 4.24 | -6.22 |
| 335.4826 | 10.76 | 15.69 | 3.40 | -15.32 | 7.62 | 4.61 | -6.06 |
| 335.4896 | 11.11 | 16.61 | 6.08 | -15.46 | 6.65 | 3.37 | -5.73 |
| 335.4965 | 10.41 | 15.21 | 5.71 | -14.09 | 6.61 | 3.00 | -5.89 |
| 335.5035 | 10.87 | 17.24 | 5.77 | -16.25 | 6.45 | 3.29 | -5.55 |
| 335.5104 | 9.94 | 15.22 | 5.34 | -14.25 | 8.99 | 6.29 | -6.42 |
| 335.5174 | 10.40 | 16.88 | 10.22 | -13.44 | 10.63 | 6.82 | -8.15 |
| 335.5243 | 10.52 | 19.41 | 8.30 | -17.55 | 9.74 | 6.61 | -7.16 |
| 335.5313 | 10.87 | 16.20 | 6.47 | -14.85 | 9.82 | 8.23 | -5.36 |
| 335.5382 | 10.75 | 16.83 | 9.20 | -14.10 | 9.60 | 7.86 | -5.52 |

Swamped Boat and Life Raft

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | 5.5m Leeway Speed (cm/s) | Boat Eastward Leeway (cm/s) | Run 60 Northward Leeway (cm/s) | Life Raft Leeway Speed (cm/s) | "J" Eastward Leeway (cm/s) | Run 63 Northward Leeway (cm/s) |
|---|---|---|---|---|---|---|---|
| 335.5451 | 11.09 | 15.40 | 6.15 | -14.12 | 13.35 | 9.07 | -9.79 |
| 335.5521 | 10.98 | 17.17 | 2.60 | -16.98 | | | |
| 335.5590 | 11.45 | 18.03 | 1.29 | -17.98 | | | |
| 335.5660 | 11.33 | 17.06 | 5.51 | -16.14 | | | |
| 335.5729 | 10.75 | 17.00 | 6.97 | -15.50 | | | |
| 335.5799 | 10.40 | 17.61 | 7.58 | -15.90 | | | |
| 335.5868 | 10.40 | 14.20 | 7.79 | -11.88 | | | |
| 335.5938 | 11.21 | 17.67 | 8.50 | -15.50 | | | |
| 335.6007 | 10.86 | 18.68 | 4.42 | -18.15 | | | |
| 335.6076 | 10.74 | 17.87 | 8.58 | -15.68 | | | |
| 335.6146 | 10.63 | 18.20 | 10.59 | -14.80 | | | |
| 335.6215 | 10.74 | 18.71 | 9.26 | -16.25 | | | |
| 335.6285 | 11.32 | 18.23 | 6.35 | -17.08 | | | |
| 335.6354 | 11.20 | 19.30 | 9.50 | -16.80 | | | |
| 335.6424 | 11.32 | 19.40 | 10.24 | -16.48 | | | |
| 335.6493 | 10.86 | 17.02 | 7.52 | -15.27 | | | |
| 335.6563 | 10.97 | 17.75 | 10.90 | -14.01 | | | |
| 335.6632 | 10.74 | 19.26 | 3.66 | -18.91 | | | |
| 335.6701 | 11.20 | 19.00 | 7.59 | -17.42 | | | |
| 335.6771 | 10.74 | 19.01 | 8.14 | -17.18 | | | |
| 335.6840 | 11.32 | 20.50 | 6.32 | -19.50 | | | |
| 335.6910 | 11.09 | 19.21 | 3.03 | -18.97 | | | |
| 335.6979 | 10.85 | 17.56 | 4.75 | -16.91 | | | |
| 335.7049 | 11.09 | 19.33 | 9.69 | -16.72 | | | |
| 335.7118 | 11.44 | 18.16 | 11.72 | -13.87 | | | |
| 335.7188 | 10.74 | 19.70 | 9.66 | -17.17 | | | |
| 335.7257 | 11.67 | 16.83 | 7.63 | -15.00 | | | |
| 335.7326 | 10.85 | 17.34 | 9.91 | -14.23 | | | |
| 335.7396 | 10.74 | 20.28 | 9.72 | -17.80 | | | |
| 335.7465 | 11.09 | 21.78 | 11.20 | -18.68 | | | |

Life Raft "H",Std.Conf. Run 64

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) |
|---|---|---|---|---|
| 334.8090 | 8.12 | 26.62 | 7.43 | -25.56 |
| 334.8160 | 8.12 | 27.30 | 5.94 | -26.65 |
| 334.8229 | 8.58 | 25.42 | 5.77 | -24.76 |
| 334.8299 | 8.46 | 28.01 | 6.62 | -27.22 |
| 334.8368 | 8.35 | 26.82 | 7.51 | -25.74 |
| 334.8438 | 8.46 | 22.84 | 7.82 | -21.46 |
| 334.8507 | 8.12 | 25.29 | 6.50 | -24.44 |
| 334.8576 | 8.12 | 23.05 | 5.99 | -22.26 |
| 334.8646 | 8.92 | 25.62 | 5.85 | -24.94 |
| 334.8715 | 9.27 | 18.60 | -1.07 | -18.57 |
| 334.8785 | 8.92 | 18.54 | 0.01 | -18.54 |
| 334.8854 | 9.50 | 29.02 | -0.01 | -29.02 |
| 334.8924 | 9.84 | 23.00 | 3.37 | -22.75 |
| 334.8993 | 9.61 | 26.83 | 11.81 | -24.09 |
| 334.9063 | 8.80 | 24.19 | 0.07 | -24.19 |
| 334.9132 | 8.92 | 25.66 | 3.86 | -25.37 |
| 334.9201 | 8.80 | 28.00 | -1.12 | -27.98 |
| 334.9271 | 9.50 | 26.22 | 0.95 | -26.20 |
| 334.9340 | 9.50 | 28.35 | -4.61 | -27.97 |
| 334.9410 | 9.73 | 23.29 | 1.19 | -23.26 |
| 334.9479 | 9.61 | 22.37 | -1.62 | -22.31 |
| 334.9549 | 9.38 | 25.06 | 2.99 | -24.88 |
| 334.9618 | 9.49 | 29.50 | 5.64 | -28.96 |
| 334.9688 | 9.26 | 22.62 | 0.69 | -22.61 |
| 334.9757 | 9.96 | 28.35 | -8.50 | -27.05 |
| 334.9826 | 9.84 | 20.91 | -3.68 | -20.59 |
| 334.9896 | 10.18 | 34.31 | 9.36 | -33.01 |
| 334.9965 | 9.72 | 25.73 | -3.05 | -25.54 |
| 335.0035 | 9.03 | 24.67 | 1.57 | -24.62 |
| 335.0104 | 9.26 | 23.53 | -3.38 | -23.29 |
| 335.0174 | 9.49 | 27.30 | 5.94 | -26.65 |
| 335.0243 | 8.92 | 27.32 | 2.69 | -27.19 |
| 335.0313 | 9.27 | 26.26 | 3.28 | -26.06 |
| 335.0382 | 9.61 | 23.40 | 0.38 | -23.40 |
| 335.0451 | 8.92 | 29.64 | 4.27 | -29.33 |
| 335.0521 | 10.30 | 27.74 | -7.32 | -26.75 |
| 335.0590 | 9.38 | 24.52 | -2.01 | -24.44 |
| 335.0660 | 9.84 | 25.56 | 1.52 | -25.52 |
| 335.0729 | 9.95 | 29.06 | 4.85 | -28.65 |
| 335.0799 | 9.49 | 28.75 | 6.13 | -28.09 |
| 335.0868 | 9.03 | 31.86 | 10.87 | -29.95 |
| 335.0938 | 8.23 | 29.75 | 1.39 | -29.72 |
| 335.1007 | 9.38 | 27.13 | -0.18 | -27.13 |
| 335.1076 | 9.72 | 27.41 | 7.75 | -26.29 |
| 335.1146 | 9.26 | 22.88 | 0.58 | -22.87 |
| 335.1215 | 8.80 | 23.03 | 0.22 | -23.03 |
| 335.1285 | 10.19 | 26.85 | 1.00 | -26.83 |
| 335.1354 | 9.38 | 28.06 | 7.62 | -27.00 |

Life Raft "H",Std.Conf. Run 64

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) |
|---|---|---|---|---|
| 335.1424 | 9.49 | 28.44 | -1.59 | -28.40 |
| 335.1493 | 8.80 | 28.34 | 2.27 | -28.24 |
| 335.1563 | 9.03 | 29.96 | 7.61 | -28.97 |
| 335.1632 | 9.03 | 32.12 | 4.68 | -31.77 |
| 335.1701 | 8.46 | 34.03 | 2.78 | -33.91 |
| 335.1771 | 9.15 | 24.67 | 5.27 | -24.10 |
| 335.1840 | 8.80 | 25.86 | 3.94 | -25.56 |
| 335.1910 | 8.23 | 27.07 | 6.04 | -26.38 |
| 335.1979 | 9.15 | 23.91 | 1.88 | -23.83 |
| 335.2049 | 9.61 | 22.80 | 8.74 | -21.06 |
| 335.2118 | 9.15 | 29.10 | 7.65 | -28.08 |
| 335.2188 | 8.12 | 22.95 | 12.69 | -19.12 |
| 335.2257 | 8.69 | 27.01 | 11.34 | -24.51 |
| 335.2326 | 8.12 | 25.64 | 8.94 | -24.03 |
| 335.2396 | 8.35 | 22.45 | 2.31 | -22.33 |
| 335.2465 | 8.69 | 21.06 | 4.20 | -20.64 |
| 335.2535 | 9.95 | 20.38 | 2.70 | -20.21 |
| 335.2604 | 9.49 | 34.42 | 14.84 | -31.06 |
| 335.2674 | 8.57 | 25.45 | 11.61 | -22.65 |
| 335.2743 | 8.23 | 30.71 | 18.69 | -24.36 |
| 335.2813 | 8.57 | 28.15 | 18.59 | -21.13 |
| 335.2882 | 9.72 | 26.24 | 9.18 | -24.58 |
| 335.2951 | 8.80 | 29.51 | 9.36 | -27.99 |
| 335.3021 | 9.84 | 27.53 | 19.11 | -19.82 |
| 335.3090 | 9.49 | 27.80 | 11.11 | -25.49 |
| 335.3160 | 9.26 | 37.00 | 14.60 | -34.00 |
| 335.3229 | 9.38 | 34.25 | 5.56 | -33.79 |
| 335.3299 | 9.72 | 32.80 | 13.29 | -29.99 |
| 335.3368 | 9.15 | 31.17 | 16.70 | -26.32 |
| 335.3438 | 9.03 | 35.36 | 21.26 | -28.26 |
| 335.3507 | 8.00 | 33.22 | 12.16 | -30.92 |
| 335.3576 | 11.46 | 32.84 | 22.75 | -23.68 |
| 335.3646 | 10.88 | 33.57 | 20.36 | -26.69 |
| 335.3715 | 10.88 | 34.25 | 15.31 | -30.63 |
| 335.3785 | 11.00 | 32.83 | 25.42 | -20.78 |
| 335.3854 | 10.42 | 34.10 | 22.19 | -25.89 |
| 335.3924 | 9.72 | 29.41 | 19.91 | -21.65 |
| 335.3993 | 8.57 | 31.50 | 17.52 | -26.18 |
| 335.4063 | 10.41 | 33.82 | 25.42 | -22.30 |
| 335.4132 | 9.03 | 30.97 | 23.00 | -20.74 |
| 335.4201 | 10.53 | 30.62 | 24.27 | -18.66 |
| 335.4271 | 10.30 | 31.98 | 25.59 | -19.17 |
| 335.4340 | 10.76 | 29.24 | 24.31 | -16.24 |
| 335.4410 | 11.57 | 29.18 | 18.70 | -22.39 |
| 335.4479 | 10.06 | 32.17 | 23.38 | -22.10 |
| 335.4549 | 10.64 | 28.14 | 16.81 | -22.56 |
| 335.4618 | 10.07 | 28.49 | 18.10 | -22.00 |
| 335.4688 | 10.99 | 29.41 | 19.44 | -22.07 |

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) |
|---|---|---|---|---|
| 335.4757 | 10.76 | 28.64 | 21.39 | -19.04 |
| 335.4826 | 10.76 | 31.53 | 22.20 | -22.40 |
| 335.4896 | 11.11 | 29.57 | 21.50 | -20.30 |
| 335.4965 | 10.41 | 20.95 | 14.61 | -15.01 |
| 335.5035 | 10.87 | 26.63 | 19.18 | -18.48 |
| 335.5104 | 9.94 | 27.09 | 17.35 | -20.80 |
| 335.5174 | 10.40 | 24.12 | 14.01 | -19.64 |
| 335.5243 | 10.52 | 26.63 | 22.15 | -14.78 |
| 335.5313 | 10.87 | 28.73 | 21.28 | -19.31 |
| 335.5382 | 10.75 | 29.47 | 23.61 | -17.64 |
| 335.5451 | 11.09 | 29.77 | 24.16 | -17.40 |
| 335.5521 | 10.98 | 30.68 | 17.85 | -24.95 |
| 335.5590 | 11.45 | 25.18 | 20.26 | -14.95 |
| 335.5660 | 11.33 | 26.18 | 17.61 | -19.38 |
| 335.5729 | 10.75 | 29.53 | 26.45 | -13.13 |
| 335.5799 | 10.40 | 28.61 | 25.27 | -13.42 |
| 335.5868 | 10.40 | 29.24 | 26.18 | -13.03 |
| 335.5938 | 11.21 | 33.62 | 28.63 | -17.63 |
| 335.6007 | 10.86 | 31.43 | 28.70 | -12.80 |
| 335.6076 | 10.74 | 29.81 | 25.62 | -15.23 |
| 335.6146 | 10.63 | 32.29 | 24.89 | -20.57 |
| 335.6215 | 10.74 | 33.42 | 31.68 | -10.63 |
| 335.6285 | 11.32 | 31.03 | 28.15 | -13.04 |
| 335.6354 | 11.20 | 29.73 | 20.35 | -21.67 |
| 335.6424 | 11.32 | 22.81 | 18.75 | -12.99 |
| 335.6493 | 10.86 | 32.72 | 29.73 | -13.66 |
| 335.6563 | 10.97 | 32.34 | 29.08 | -14.16 |
| 335.6632 | 10.74 | 33.14 | 30.18 | -13.68 |
| 335.6701 | 11.20 | 32.53 | 27.96 | -16.61 |
| 335.6771 | 10.74 | 32.26 | 29.60 | -12.85 |
| 335.6840 | 11.32 | 31.45 | 26.42 | -17.07 |
| 335.6910 | 11.09 | 32.34 | 29.08 | -14.16 |
| 335.6979 | 10.85 | 32.41 | 29.68 | -13.03 |
| 335.7049 | 11.09 | 31.95 | 27.05 | -17.01 |
| 335.7118 | 11.44 | 35.37 | 32.49 | -13.98 |
| 335.7188 | 10.74 | 34.93 | 31.24 | -15.62 |
| 335.7257 | 11.67 | 28.40 | 23.91 | -15.32 |
| 335.7326 | 10.85 | 29.96 | 26.19 | -14.55 |
| 335.7396 | 10.74 | 29.13 | 27.22 | -10.39 |
| 335.7465 | 11.09 | 31.05 | 30.04 | -7.85 |
| 335.7535 | 10.86 | 32.57 | 30.89 | -10.32 |
| 335.7604 | 11.32 | 27.58 | 25.51 | -10.48 |
| 335.7674 | 10.74 | 34.24 | 29.93 | -16.63 |
| 335.7743 | 11.32 | 30.07 | 25.49 | -15.94 |
| 335.7813 | 10.86 | 31.39 | 30.17 | -8.67 |
| 335.7882 | 10.86 | 27.41 | 23.43 | -14.22 |
| 335.7951 | 10.86 | 27.00 | 23.48 | -13.33 |
| 335.8021 | 10.86 | 24.96 | 19.32 | -15.80 |

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) |
|---|---|---|---|---|
| 335.8090 | 10.75 | 27.72 | 25.80 | -10.14 |
| 335.8160 | 11.09 | 27.30 | 25.14 | -10.64 |
| 335.8229 | 10.98 | 28.00 | 26.06 | -10.24 |
| 335.8299 | 9.48 | 27.17 | 24.96 | -10.72 |
| 335.8368 | 10.28 | 26.17 | 25.99 | -3.07 |
| 335.8438 | 9.94 | 31.17 | 30.71 | -5.38 |
| 335.8507 | 10.52 | 28.79 | 27.50 | -8.53 |
| 335.8576 | 10.06 | 29.64 | 29.48 | -3.08 |
| 335.8646 | 10.17 | 27.61 | 26.13 | -8.90 |
| 335.8715 | 10.87 | 27.79 | 26.52 | -8.30 |
| 335.8785 | 10.64 | 26.88 | 26.19 | -6.04 |
| 335.8854 | 10.76 | 26.59 | 24.85 | -9.46 |
| 335.8924 | 10.99 | 31.90 | 31.29 | -6.22 |
| 335.8993 | 11.23 | 31.98 | 29.33 | -12.74 |
| 335.9063 | 10.99 | 30.02 | 29.68 | -4.52 |
| 335.9132 | 11.58 | 28.43 | 26.40 | -10.53 |
| 335.9201 | 11.93 | 26.45 | 24.77 | -9.28 |
| 335.9271 | 10.53 | 23.35 | 23.28 | -1.86 |
| 335.9340 | 10.88 | 24.25 | 23.18 | -7.13 |
| 335.9410 | 9.84 | 27.01 | 25.09 | -10.01 |
| 335.9479 | 9.72 | 22.74 | 20.23 | -10.38 |
| 335.9549 | 9.61 | 29.07 | 28.55 | -5.45 |
| 335.9618 | 9.61 | 23.00 | 22.91 | -2.01 |
| 335.9688 | 10.42 | 21.69 | 21.60 | 2.00 |
| 335.9757 | 10.07 | 27.12 | 26.35 | -6.41 |
| 335.9826 | 9.96 | 23.92 | 23.38 | -5.08 |
| 335.9896 | 10.31 | 24.88 | 24.78 | -2.29 |
| 335.9965 | 10.19 | 22.00 | 21.99 | -0.89 |
| 336.0035 | 9.85 | 27.14 | 26.84 | -4.01 |
| 336.0104 | 9.73 | 29.02 | 29.02 | -0.01 |
| 336.0174 | 10.19 | 25.16 | 25.16 | -0.16 |
| 336.0243 | 9.73 | 25.66 | 25.65 | 0.71 |
| 336.0313 | 8.70 | 27.96 | 27.88 | 2.11 |
| 336.0382 | 10.08 | 27.18 | 26.62 | 5.49 |
| 336.0451 | 9.04 | 20.17 | 20.17 | 0.28 |
| 336.0521 | 9.62 | 24.15 | 23.92 | -3.32 |
| 336.0590 | 8.93 | 22.67 | 22.52 | -2.62 |
| 336.0660 | 9.04 | 27.19 | 27.18 | 0.72 |
| 336.0729 | 9.62 | 27.22 | 27.09 | -2.59 |
| 336.0799 | 9.05 | 25.40 | 23.37 | 9.96 |
| 336.0868 | 9.39 | 27.84 | 27.72 | -2.54 |
| 336.0938 | 9.62 | 20.59 | 20.59 | -0.19 |
| 336.1007 | 8.94 | 22.91 | 22.45 | 4.55 |
| 336.1076 | 9.05 | 25.72 | 25.45 | 3.67 |
| 336.1146 | 8.82 | 23.45 | 22.63 | 6.15 |
| 336.1215 | 8.94 | 22.56 | 22.30 | 3.39 |
| 336.1285 | 8.94 | 18.88 | 18.81 | -1.62 |
| 336.1354 | 9.06 | 19.74 | 19.44 | 3.45 |

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) |
|---|---|---|---|---|
| 336.1424 | 8.83 | 25.87 | 25.75 | 2.49 |
| 336.1493 | 8.48 | 26.87 | 25.37 | 8.87 |
| 336.1563 | 8.37 | 26.24 | 25.57 | 5.91 |
| 336.1632 | 8.03 | 29.84 | 27.96 | 10.44 |
| 336.1701 | 7.80 | 28.92 | 25.36 | 13.89 |
| 336.1771 | 8.03 | 25.33 | 22.06 | 12.45 |
| 336.1840 | 8.04 | 27.07 | 23.95 | 12.62 |
| 336.1910 | 7.70 | 25.61 | 23.71 | 9.68 |
| 336.1979 | 7.35 | 20.63 | 15.83 | 13.23 |
| 336.2049 | 7.58 | 20.40 | 12.67 | 15.99 |
| 336.2118 | 7.93 | 21.06 | 17.13 | 12.26 |
| 336.2188 | 8.16 | 24.26 | 14.72 | 19.29 |
| 336.2257 | 8.16 | 19.37 | 10.01 | 16.58 |
| 336.2326 | 7.59 | 23.39 | 9.98 | 21.15 |
| 336.2396 | 7.70 | 21.16 | 12.37 | 17.17 |
| 336.2465 | 7.71 | 19.93 | 11.43 | 16.33 |
| 336.2535 | 7.82 | 22.12 | 17.38 | 13.68 |
| 336.2604 | 7.25 | 20.15 | 8.92 | 18.07 |
| 336.2674 | 7.14 | 21.48 | 14.45 | 15.90 |
| 336.2743 | 6.23 | 21.63 | 17.17 | 13.16 |
| 336.2813 | 6.12 | 18.10 | 13.11 | 12.47 |
| 336.2882 | 5.90 | 19.80 | 18.15 | 7.91 |
| 336.2951 | 5.90 | 23.22 | 17.64 | 15.10 |
| 336.3021 | 5.57 | 20.58 | 15.91 | 13.04 |
| 336.3090 | 6.01 | 16.37 | 7.66 | 14.46 |
| 336.3160 | 6.35 | 16.27 | 6.34 | 14.98 |
| 336.3229 | 6.24 | 16.04 | 8.16 | 13.81 |
| 336.3299 | 6.46 | 17.44 | 7.55 | 15.72 |
| 336.3368 | 6.24 | 13.91 | 4.02 | 13.31 |
| 336.3438 | 5.91 | 9.18 | -0.50 | 9.16 |
| 336.3507 | 5.01 | 9.82 | 1.67 | 9.67 |
| 336.3576 | 4.68 | 12.88 | 2.81 | 12.57 |
| 336.3646 | 4.80 | 10.24 | -1.98 | 10.05 |
| 336.3715 | 5.35 | 11.60 | -4.45 | 10.71 |
| 336.3785 | 4.91 | 9.08 | -4.70 | 7.77 |
| 336.3854 | 5.24 | 10.62 | -4.78 | 9.48 |
| 336.3924 | 4.80 | 11.51 | -1.28 | 11.44 |
| 336.3993 | 4.36 | 15.72 | 3.58 | 15.31 |
| 336.4063 | 4.69 | 19.15 | 0.38 | 19.15 |
| 336.4132 | 6.25 | 23.53 | 0.88 | 23.51 |
| 336.4201 | 6.37 | 24.37 | -1.22 | 24.34 |
| 336.4271 | 6.03 | 27.76 | 0.12 | 27.76 |
| 336.4340 | 6.60 | 26.82 | -2.89 | 26.66 |
| 336.4410 | 7.30 | 30.00 | -11.62 | 27.66 |
| 336.4479 | 9.50 | 26.69 | -8.61 | 25.26 |
| 336.4549 | 10.55 | 29.35 | -8.91 | 27.97 |
| 336.4618 | 10.55 | 30.21 | -12.61 | 27.45 |
| 336.4688 | 10.55 | 32.20 | -12.86 | 29.52 |

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| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) |
|---|---|---|---|---|
| 336.4757 | 11.14 | 29.41 | -12.48 | 26.63 |
| 336.4826 | 11.37 | 30.44 | -15.55 | 26.17 |
| 336.4896 | 11.72 | 29.35 | -17.48 | 23.58 |
| 336.4965 | 12.07 | 35.08 | -22.12 | 27.23 |
| 336.5035 | 11.72 | 31.00 | -12.75 | 28.26 |
| 336.5104 | 11.25 | 34.95 | -19.43 | 29.06 |
| 336.5174 | 11.84 | 35.21 | -17.47 | 30.57 |
| 336.5243 | 13.60 | 38.38 | -20.13 | 32.68 |
| 336.5313 | 12.78 | 37.20 | -14.49 | 34.26 |
| 336.5382 | 14.07 | 37.24 | -18.63 | 32.24 |
| 336.5451 | 14.19 | 35.87 | -18.25 | 30.88 |
| 336.5521 | 13.94 | 38.08 | -23.68 | 29.82 |
| 336.5590 | 14.53 | 39.36 | -18.96 | 34.50 |
| 336.5660 | 15.36 | 36.32 | -17.21 | 31.99 |
| 336.5729 | 15.48 | 40.67 | -27.62 | 29.85 |
| 336.5799 | 14.89 | 44.01 | -31.05 | 31.20 |
| 336.5868 | 15.12 | 37.77 | -21.75 | 30.88 |
| 336.5938 | 15.01 | 42.61 | -25.05 | 34.46 |
| 336.6007 | 15.83 | 41.65 | -26.61 | 32.04 |
| 336.6076 | 15.95 | 42.02 | -23.14 | 35.08 |
| 336.6146 | 16.90 | 41.48 | -26.06 | 32.28 |
| 336.6215 | 17.25 | 44.03 | -32.85 | 29.32 |
| 336.6285 | 16.66 | 51.34 | -23.94 | 45.42 |
| 336.6354 | 16.42 | 52.50 | -23.87 | 46.76 |
| 336.6424 | 17.61 | 52.82 | -34.62 | 39.89 |
| 336.6493 | 17.13 | 53.70 | -40.03 | 35.79 |
| 336.6563 | 17.02 | 51.96 | -32.34 | 40.67 |
| 336.6632 | 17.73 | 45.92 | -30.62 | 34.22 |
| 336.6701 | 18.69 | 50.06 | -36.81 | 33.92 |
| 336.6771 | 17.50 | 52.26 | -32.78 | 40.69 |
| 336.6840 | 18.34 | 45.42 | -31.03 | 33.16 |
| 336.6910 | 17.87 | 45.85 | -28.84 | 35.65 |
| 336.6979 | 17.99 | 42.47 | -27.12 | 32.69 |
| 336.7049 | 18.12 | 43.65 | -33.83 | 27.58 |
| 336.7118 | 17.29 | 44.71 | -29.96 | 33.20 |
| 336.7188 | 18.01 | 42.76 | -33.15 | 27.01 |
| 336.7257 | 17.42 | 48.17 | -34.50 | 33.62 |
| 336.7326 | 18.14 | 48.29 | -28.21 | 39.20 |
| 336.7396 | 18.73 | 44.95 | -25.17 | 37.24 |
| 336.7465 | 18.61 | 45.24 | -19.89 | 40.64 |
| 336.7535 | 17.66 | 41.42 | -23.74 | 33.94 |
| 336.7604 | 18.25 | 43.80 | -27.02 | 34.48 |
| 336.7674 | 17.78 | 40.86 | -27.23 | 30.46 |
| 336.7743 | 17.31 | 40.62 | -21.38 | 34.54 |
| 336.7813 | 16.84 | 43.33 | -27.15 | 33.77 |

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) |
|---|---|---|---|---|
| 336.7882 | 16.60 | 27.68 | -22.24 | 16.49 |
| 336.7951 | 17.44 | 26.79 | -21.55 | 15.92 |
| 336.8021 | 16.62 | 22.53 | -14.50 | 17.25 |
| 336.8090 | 16.87 | 25.12 | -17.31 | 18.20 |
| 336.8160 | 15.94 | 21.45 | -9.83 | 19.06 |
| 336.8229 | 16.42 | 21.69 | -10.46 | 19.00 |
| 336.8299 | 17.25 | 20.66 | -6.76 | 19.52 |
| 336.8368 | 16.20 | 21.90 | -5.33 | 21.24 |
| 336.8438 | 15.73 | 21.21 | -2.83 | 21.02 |
| 336.8507 | 14.80 | 16.91 | 0.71 | 16.89 |
| 336.8576 | 13.28 | 12.07 | 0.64 | 12.06 |
| 336.8646 | 12.46 | 13.17 | 5.47 | 11.98 |
| 336.8715 | 11.66 | 13.45 | 1.60 | 13.35 |
| 336.8785 | 11.08 | 9.85 | 0.96 | 9.80 |
| 336.8854 | 9.59 | 8.92 | 2.86 | 8.45 |
| 336.8924 | 9.13 | 11.33 | 4.66 | 10.32 |
| 336.8993 | 10.02 | 9.32 | -0.14 | 9.32 |
| 336.9063 | 9.66 | 8.06 | 4.82 | 6.46 |
| 336.9132 | 10.11 | 10.39 | 1.17 | 10.33 |
| 336.9201 | 7.70 | 6.93 | 2.40 | 6.50 |
| 336.9271 | 8.37 | 7.25 | 0.11 | 7.25 |
| 336.9340 | 8.93 | 7.60 | 1.56 | 7.44 |
| 336.9410 | 9.39 | 4.87 | 3.58 | 3.30 |
| 336.9479 | 9.02 | 4.51 | 3.63 | 2.67 |
| 336.9549 | 8.22 | 5.39 | 0.73 | 5.34 |
| 336.9618 | 8.44 | 3.77 | 2.13 | 3.11 |
| 336.9688 | 8.45 | 6.28 | 0.78 | 6.23 |
| 336.9757 | 8.68 | 6.80 | -2.72 | 6.23 |
| 336.9826 | 8.21 | 6.72 | 0.80 | 6.68 |
| 336.9896 | 9.01 | 8.21 | 2.74 | 7.74 |
| 336.9965 | 9.23 | 9.43 | 6.71 | 6.63 |
| 337.0035 | 9.11 | 8.65 | 4.68 | 7.28 |
| 337.0104 | 9.46 | 8.59 | 5.71 | 6.42 |
| 337.0174 | 8.88 | 9.93 | 6.23 | 7.73 |
| 337.0243 | 8.31 | 9.65 | 4.31 | 8.64 |
| 337.0313 | 8.41 | 9.04 | 5.66 | 7.05 |
| 337.0382 | 8.29 | 10.22 | 4.51 | 9.17 |
| 337.0451 | 8.29 | 11.85 | 8.33 | 8.43 |
| 337.0521 | 8.52 | 6.45 | 3.86 | 5.17 |
| 337.0590 | 8.51 | 10.48 | 7.12 | 7.69 |
| 337.0660 | 7.94 | 9.88 | 2.12 | 9.65 |
| 337.0729 | 8.40 | 7.60 | 3.93 | 6.51 |
| 337.0799 | 8.28 | 9.13 | 5.58 | 7.23 |
| 337.0868 | 8.29 | 8.25 | 3.79 | 7.32 |
| 337.0938 | 8.75 | 9.56 | 4.65 | 8.35 |
| 337.1007 | 8.52 | 8.53 | 3.89 | 7.59 |
| 337.1076 | 8.30 | 8.79 | 6.66 | 5.74 |
| 337.1146 | 8.06 | 10.62 | 4.27 | 9.72 |

Life Raft "H",Capsized, Run 64

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) |
|---|---|---|---|---|
| 337.1215 | 8.29 | 10.18 | 7.44 | 6.95 |
| 337.1285 | 8.75 | 10.58 | 8.23 | 6.64 |
| 337.1354 | 9.22 | 10.38 | 6.52 | 8.08 |
| 337.1424 | 9.68 | 9.55 | 6.97 | 6.53 |
| 337.1493 | 9.33 | 11.32 | 6.40 | 9.34 |
| 337.1563 | 9.67 | 10.50 | 4.62 | 9.43 |
| 337.1632 | 9.55 | 12.88 | 8.05 | 10.05 |
| 337.1701 | 9.79 | 10.92 | 6.72 | 8.60 |
| 337.1771 | 10.37 | 12.56 | 6.13 | 10.96 |
| 337.1840 | 9.67 | 12.34 | 7.85 | 9.53 |
| 337.1910 | 10.02 | 10.18 | 7.44 | 6.95 |
| 337.1979 | 9.90 | 12.80 | 7.79 | 10.16 |
| 337.2049 | 9.56 | 10.91 | 7.07 | 8.32 |
| 337.2118 | 8.98 | 10.93 | 7.41 | 8.03 |
| 337.2188 | 9.09 | 9.99 | 5.54 | 8.31 |
| 337.2257 | 8.86 | 10.73 | 6.88 | 8.24 |
| 337.2326 | 8.98 | 11.26 | 6.14 | 9.44 |
| 337.2396 | 8.98 | 12.26 | 7.58 | 9.63 |
| 337.2465 | 9.21 | 9.93 | 6.23 | 7.73 |
| 337.2535 | 9.32 | 11.12 | 5.35 | 9.75 |
| 337.2604 | 9.21 | 9.67 | 5.78 | 7.76 |
| 337.2674 | 9.67 | 11.60 | 5.90 | 9.99 |
| 337.2743 | 9.32 | 12.49 | 6.47 | 10.68 |
| 337.2813 | 8.40 | 11.18 | 7.17 | 8.58 |
| 337.2882 | 10.01 | 10.72 | 5.33 | 9.30 |
| 337.2951 | 9.67 | 9.65 | 4.31 | 8.64 |
| 337.3021 | 10.01 | 11.93 | 5.40 | 10.64 |
| 337.3090 | 9.67 | 11.88 | 6.00 | 10.25 |
| 337.3160 | 9.90 | 9.60 | 5.52 | 7.86 |
| 337.3229 | 9.44 | 12.56 | 6.13 | 10.96 |
| 337.3299 | 10.02 | 13.09 | 6.08 | 11.59 |
| 337.3368 | 9.67 | 9.04 | 4.71 | 7.72 |
| 337.3438 | 9.67 | 9.12 | 5.92 | 6.94 |
| 337.3507 | 10.14 | 11.68 | 5.56 | 10.28 |
| 337.3576 | 9.09 | 11.76 | 3.64 | 11.18 |
| 337.3646 | 9.33 | 12.65 | 3.42 | 12.18 |
| 337.3715 | 10.72 | 8.77 | 4.60 | 7.46 |
| 337.3785 | 9.67 | 10.39 | 6.17 | 8.36 |
| 337.3854 | 9.32 | 11.76 | 2.40 | 11.52 |
| 337.3924 | 9.89 | 9.62 | 3.52 | 8.95 |
| 337.3993 | 9.08 | 11.28 | 5.53 | 9.83 |
| 337.4063 | 10.82 | 10.77 | 6.20 | 8.81 |
| 337.4132 | 10.12 | 12.55 | 8.72 | 9.03 |
| 337.4201 | 10.70 | 12.37 | 5.68 | 10.99 |
| 337.4271 | 11.28 | 12.15 | 9.20 | 7.93 |
| 337.4340 | 9.77 | 12.65 | 6.66 | 10.76 |
| 337.4410 | 10.34 | 14.87 | 12.27 | 8.40 |
| 337.4479 | 10.22 | 13.67 | 11.91 | 6.72 |

Life Raft "H",Capsized, Run 64

| Yearday 1995 (UTC) | 10m Wind Speed (m/s) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) |
|---|---|---|---|---|
| 337.4549 | 10.91 | 15.20 | 13.85 | 6.26 |
| 337.4618 | 9.86 | 15.73 | 12.84 | 9.09 |
| 337.4688 | 10.20 | 12.81 | 10.09 | 7.89 |
| 337.4757 | 10.53 | 14.24 | 12.62 | 6.59 |
| 337.4826 | 9.60 | 13.24 | 11.70 | 6.19 |
| 337.4896 | 8.90 | 12.44 | 10.97 | 5.87 |
| 337.4965 | 8.21 | 9.57 | 9.34 | 2.10 |
| 337.5035 | 8.43 | 12.32 | 12.12 | 2.23 |
| 337.5104 | 7.74 | 8.96 | 8.96 | -0.02 |

D-B Life Raft, Capsized, Run 22

| Yearday 1992 (UTC) | 10m Wind Speed (m/s) | Leeway Speed (cm/s) | Eastward Leeway (cm/s) | Northward Leeway (cm/s) |
|---|---|---|---|---|
| 341.1493 | 17.18 | 18.38 | 15.70 | 9.57 |
| 341.1563 | 18.06 | 19.50 | 18.61 | 5.82 |
| 341.1632 | 17.44 | 15.42 | 15.42 | 0.09 |
| 341.1701 | 17.13 | 10.84 | -1.25 | -10.77 |
| 341.1771 | 18.06 | 16.49 | -16.28 | -2.64 |
| 341.1840 | 17.54 | 14.41 | -14.21 | -2.40 |
| 341.1910 | 17.85 | 16.81 | -15.67 | -6.08 |
| 341.1979 | 16.20 | 14.76 | -14.28 | -3.74 |
| 341.2049 | 16.72 | 17.08 | -16.83 | -2.88 |
| 341.2118 | 18.21 | 17.20 | -15.96 | -6.42 |
| 341.2188 | 18.42 | 17.40 | -15.83 | -7.23 |
| 341.2257 | 18.21 | 14.83 | -13.99 | -4.92 |
| 341.2326 | 17.95 | 14.99 | -12.65 | -8.05 |
| 341.2396 | 17.59 | 16.60 | -15.25 | -6.55 |
| 341.2465 | 17.85 | 13.63 | -13.47 | -2.09 |
| 341.2535 | 17.23 | 14.71 | -12.70 | -7.42 |
| 341.2604 | 17.34 | 17.24 | -15.33 | -7.89 |
| 341.2674 | 17.65 | 15.22 | -13.65 | -6.73 |
| 341.2743 | 17.65 | 14.83 | -13.99 | -4.92 |
| 341.2813 | 17.70 | 15.59 | -15.10 | -3.87 |
| 341.2882 | 17.85 | 16.80 | -15.44 | -6.63 |
| 341.2951 | 18.78 | 19.80 | -18.19 | -7.81 |
| 341.3021 | 17.18 | 19.40 | -17.90 | -7.47 |
| 341.3090 | 18.16 | 16.88 | -16.65 | -2.80 |
| 341.3160 | 18.57 | 15.80 | -14.52 | -6.24 |
| 341.3229 | 18.83 | 16.94 | -16.59 | -3.43 |
| 341.3299 | 18.11 | 15.78 | -15.28 | -3.95 |
| 341.3368 | 18.62 | 12.49 | -6.53 | -10.64 |
| 341.3438 | 18.47 | 14.41 | -12.99 | -6.23 |
| 341.3507 | 18.42 | 16.62 | -14.94 | -7.29 |
| 341.3576 | 18.47 | 10.65 | -9.34 | -5.10 |
| 341.3646 | 18.62 | 17.46 | -16.54 | -5.58 |
| 341.3715 | 17.44 | 17.46 | -16.54 | -5.58 |
| 341.3785 | 17.70 | 16.60 | -15.25 | -6.55 |
| 341.3854 | 17.49 | 12.01 | -11.26 | -4.18 |
| 341.3924 | 17.75 | 13.84 | -12.29 | -6.37 |